

## **Section 16130**

### **Boxes**

**SECTION 16130****BOXES****PART 1 – GENERAL****1.1 Related Documents**

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

**1.2 Summary**

This section specifies the furnishing and installation of outlet boxes, floor boxes, junction boxes and pull boxes.

**1.3 Reference Standards**

1. ANSI/NEMA Publication No. OS 1 - Sheet-steel Outlet Boxes, Device Boxes, Covers and Box Supports.
2. ANSI/UL 514A - Metallic Outlet Boxes.
3. ANSI/UL 514B - Fittings for Conduit and Outlet Boxes.
4. B.S.

**1.4 Submittals**

Provide manufacturers product data and sample.

**PART 2 - PRODUCTS****2.1 Outlet Boxes**

1. Flush Device Boxes: Provide galvanized steel boxes of sufficient size to accommodate wiring devices to be installed at outlet. Provide an extension ring for the device(s) to be installed. Square or rectangular boxes may be used. Unless otherwise noted, provide minimum 38.1mm (1-1/2 inch) deep by 101.6mm (4-inch) square minimum size box.
2. Exposed Device Boxes: Provide FS or FD cast boxes for surface mounting in areas having exposed rigid steel conduit systems.

## 2.1 Outlet Boxes (cont'd)

3. Boxes for Lighting Fixtures: Provide galvanized steel octagonal boxes with fixture stud supports and attachments as required to properly support ceiling and bracket-type lighting fixtures. Unless otherwise noted, provide 38.1mm (1-1/2 inch) deep by 101.6mm (4-inch) box.
4. Function Boxes and Pull Boxes: Galvanized steel or PVC type boxes with screw-on or hinged cover, code gauge and size to carry conduit bushes and wires.
5. Blank Cover Plate: Blank cover plate to be installed on outlet boxes which has no apparatus installed or where apparatus are installed but does not have suitable cover for box. Blank cover plates for wall outlets are to be attached by a bridge for horizontal and vertical adjustments.
6. Molded Plastic Outlet Boxes:
  - A. Type: boxes and covers used with PVC conduit systems are to be heavy gauge pressure molded plastic, minimum 2mm thick, self extinguishing, with softening point not less than 85 deg. C.Boxes are to have provision for securely terminating conduits and are to be manufacturer's standard for required application.
  - B. Fittings: boxes are to have brass inset threads to receive cover screws and for mounting devices or accessories, push-fit brass earth terminals and steel insert clips to provide additional support for pendants or for heat conduction. Neoprene gaskets are to be provided for weatherproof installation.
  - C. Switch Boxes: Not permitted.
  - D. Listing: UL 514.

## 2.2 Floor Boxes

1. Box: Provide 63.5mm (2-1/2") cast-iron floor boxes with fully adjustable tops, appropriate cover plates and fittings (water tight). Boxes must be drilled and tapped for conduit openings.
2. Cover: Furnish Brass finished cover plates with rubber gaskets to become water tight. Provide wide flange cover plates for carpeted areas.
3. Listing; UL 514

### **2.3 Junction and Pull Boxes**

1. Construction. Provide galvanized steel boxes conforming to NEC Article 370.
2. Interior Spaces. Provide NEMA 1 (IP20) type boxes at least 4 inches deep.
3. Exterior Spaces. Provide NEMA 4X (non-corrosive and water tight) type boxes at least 101.6mm (4 inches) deep.
4. Embedded. Provide NEMA 4 (non-corrosive and water tight) cast iron type with flush flanged cover when cast in concrete.

## **PART 3 - EXECUTION**

### **3.1 Outlet Boxes**

1. Flush Boxes: Unless otherwise indicated, mount all outlet boxes flush within 1/4 inch of the finished wall or ceiling line. Provide galvanized steel extension rings where required to extend the box forward in conformance to NEC requirements. Attach ring with at least two machine screws. Securely fasten outlet boxes. Provide plaster covers for all boxes in plastered walls and ceilings.
2. Fixture Boxes: Where boxes for suspended lighting fixtures are attached to and supported from suspended ceilings, adequately distribute the load over the ceiling support members.
3. Mounting Height: Mounting height of a wall-mounted outlet box means the height from finished floor to horizontal center line of the cover plate. Where outlets are indicated adjacent to each other, mount these outlets in a symmetrical pattern with all tops at the same elevation. Where outlets are indicated adjacent, but with different mounting heights, line up outlets to form a symmetrical vertical pattern on the wall. Verify the final location of each outlet with Engineer before rough-in. Remove and relocate any outlet box placed in an unsuitable location.
4. Back-to-Back Boxes: Do not connect outlet boxes back to back unless approval is obtained from the Engineer. Where such a connection is necessary to complete a particular installation, fill the voids around the wire between the boxes with sound insulating material.
5. Box Openings: Provide only the conduit openings necessary to accommodate the conduits at the individual location.
6. Insulation: Provide insulation behind outlet boxes mounted in exterior walls to prevent condensation inboxes.

### **3.2 Floor Boxes**

Verify locations of all floor boxes with the Engineer before installation. Completely envelope floor boxes in concrete except at the top. Increase slab thickness at boxes if required to obtain a minimum of 25mm of concrete below bottom of box. Adjust covers flush with finished floor.

### **3.3 Junction and Pull Boxes**

1. Installation: Install boxes as required to facilitate cable installation in raceway systems. Generally provide boxes in conduit runs of more than 20 meters or as required in Section 16110.
2. Covers: Provide boxes so that covers are readily accessible and easily removable after completion of the installation. Include suitable access doors for boxes above inaccessible ceilings. Select a practical size for each box and cover.

**END OF SECTION**

**Section 16140**

**Wiring Devices**

**SECTION 16140****WIRING DEVICES****PART 1 – GENERAL****1.1 Related Documents**

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

**1.2 Summary**

This section specifies the furnishing and installation of wiring devices and device plates.

**1.3 Reference Standards**

- A. BS 3676, 1363.
- B. IEC.
- C. ANSI/UL 20 - General-Use Snap Switches.
- D. ANSI/UL 498 - Attachment Plugs and Receptacles.
- E. NEMA WD 1 - General Requirements for Wiring Devices.

**1.4 SUBMITTALS**

Provide product data on wiring devices and plates.

**PART 1 - PRODUCTS****2.1 Wall Switches**

- A. General
  - 1. Body and base shall be fully enclosed type, fire resistant, non-absorptive thermosetting phenolic compound or approved equal.
  - 2. Mounting yoke shall be corrosion resistant metal with plastic ears.

## 2.1 Wall Switches (cont'd)

3. Switches shall be flush mounted and wired with terminals of screw clamp type. Wiring terminal shall be suitable for holding two 4 mm<sup>2</sup> wires.
4. Color: Coordinate color of all other switches with the site engineer prior to ordering.
5. Rating: 15 Amps, 220 Volts, 50 Hz.

### B. Lighting Switches:

1. Lighting switches shall be snap type, in accordance with code, heavy duty, general use type, single pole, double pole, single, two-way or intermediate as shown on the drawings.
2. Quick-Make, quick-break type with silver alloy contacts in arc resisting molded base, with toggle, rocker or push-button as specified, for inductive or resistive loads up to full rated capacity, and arranged for side and/or back connection.
3. Water Proof Switch: Installed in wet area such as mechanical rooms, outdoors or as shown on drawings, with waterproof plate, water proof outlet box, IP 44 enclosure.
4. Double Pole Pilot Switch: rated as shown on the drawings, 230 V a.c., tumbler operated with red neon pilot light for off position. Switch is to be mounted to flush or surface box, as indicated on the drawings. Provided with cord outlet and cord extension to equipment controlled.
5. Approved Manufacturers  
M.K  
LEGRAND  
Pass & Seymour  
or equal and approved alternative

## 2.2 Receptacles

- A. Generally: All receptacles, unless otherwise indicated, shall have injection molded plastic base with self-adjusting, non-expanding contacts to prevent permanent distortion, flush mounted and arranged for side and/or back connection and with screw terminals accepting at least three parallel branch-circuit wires.
- B. Color: Coordinate color of all other outlets with the Engineer prior to ordering.



**2.2 Receptacles (cont')**

- C. Mounting yokes shall be corrosion resistant metal.
- D. Approved manufacturers: M.K, LEGRAND, Pass & Seymour.
- E. One or more of the following receptacles shall be provided as shown on the drawings:
  - 1. Single receptacle, polarized, grounding type, with three rectangular pin-holes two poles and earth, rated 16A, 230V.
  - 2. Duplex receptacle: are to be mounted in parallel under one common plate with break-off feature for two circuit connection.
  - 3. Weatherproof receptacle: 16A, 230V, 2 pole plus earth, enclosed in surface mounted cast-metal box and with spring-retained gasketed hinged flap cover. Receptacle splash sparkles type and proof to IP54. Outlet is to be used.
  - 4. Power Receptacles: Single Outlet, single phase, three wire, 16A, 230V, polarized with L-shaped earth contact, splash proof mold cast metal plated and matching plug. Outlet to be provided with an on-off switch.
  - 5. Industrial Socket Outlet: 3 phase, 16 A or 32A, 3P+N+E, 230-400V, single, with aluminum alloy enclosure, interlocked switch and matching plug.

**2.3 Dimmer Switch**

- A. Dimmer switches should be used to control individual incandescent or fluorescent lighting circuits.
- B. The dimmer switch shall be of electronic with thermistor control; factory calibrated, of suitable and rated for type and number of lamps indicated on the drawings for operation at 220 volts, 50 Hz.
- C. The dimmer switch shall be complete with an on/off toggle switch and a sliding dimmer capable of smooth continuous changes of lighting intensity from 1% for incandescent lamps and from 5% for fluorescent up to 100% light output.
- D. Dimmer switch shall be radio frequency interference shielded and capable of operating at 40 degrees C ambient temperature.
- E. Components are to be designed, rated and installed so that dimmer operates continuously at any setting. Components are to be installed in separate enclosure or as part of dimmer control panel as indicated on the drawings.

## 2.4 Dimming Panel:

### 1. Description for Panel:

Pre-assembled dimming panel containing (24) 16A dimmers, each protected by a 16A-1P circuit breaker, with a 16A continuous rating per dimmer circuit. Each dimmer is capable of controlling incandescent, magnetic and electronic low voltage, Hi-lume and ECO-10 fluorescent ballasts, neon/cold cathode, and non-dim loads. Load types and circuit zone assignments are selectable at the dimming panel without the need for additional equipment. Panel accepts a selectable at the dimming panel without the need for additional equipment. Panel accepts a 220-240V, 3 phase, 4 wire, 64A feeder (maximum wire size is 35mm sq), and has an integral isolation switch.

### 2. Control Unit:

Preset dimming control shall incorporate an airgap switch relay, which shall be accessible without removing the faceplate.

- Present dimming control shall meet ANSI/IEEE Std. C62.41 1980, tested to withstand voltage surges of up to 6000V and current surges of up to 200A without damage.
- Preset dimming control shall provide power failure memory.
- Faceplate shall attach using no visible means of attachment.
- Controls shall incorporate built-in wide angle Infrared Receiver, providing control via a separate Wireless Remote Control Transmitter from up to 50 feet away.
- Programming of preset scenes shall be accomplished without the use of an ENTER or STORE button.

### 3. Accessories:

- Four-Scene Control(s) shall be capable of recalling any one of four scenes, master raise / lower and off. Control shall provide access for up to 16 scenes.
- Wireless Infrared Transmitter(s) shall be capable of recalling any one of four preset scenes and off. In addition, a master raise/lower shall be provided. The transmitter shall be manufactured by the dimming system manufacturer; the range of the transmitter to any single receiver shall be at least 50 feet.

3. Accessories (cont'd)
  - System should employ common architecture for products, accessories and user interface with security panel.

## **2.5 Device Plates**

1. Finished Spaces: Use 302 stainless steel (18 percent chromium, 8 percent nickel), minimum 1mm thick.
2. Exposed Boxes in Dry Interior Spaces: Make plates of heavy cadmium-plated sheet steel. Edges of plates must be flush with edges of boxes.
3. Other Areas: Use weatherproof device plates. Provide polish chrome cast metal plates with resilient rubber or closed cell foam urethane gusted spring door covers for protection of device.

## **PART 3- EXECUTION**

### **3.1 Device Coordination**

Where items of equipment are provided under other sections of this specification or by the Engineer, provide a compatible receptacle for the cap or plug and cord of the equipment.

### **3.2 Wall Switches**

1. Location: Set wall switches in a suitable outlet box centered at the height of 110cm from the floor, except as otherwise shown. Install switch on the strike side of the door as finally hung.
2. Position: Install wall switches in a uniform position so the same direction of operation will open and close the circuits throughout the job, generally up or to the left for the ON position.

### **3.3 Receptacles**

Mount receptacles vertically with the ground on top in a suitable steel outlet box centered at the height of 30cm from the floor or as shown on the drawings. For horizontally mounted receptacles, ground should be on left.

### **3.4 Device Plates**

1. Type: Provide device plates for each outlet of the type required for service and device involved.

**3.4 Device Plates (cont'd)**

2. Ganged Devices: Mount ganged devices under a single, one-piece, device plate.
3. Engraving: Engrave plates with 3mm-high black letters, for all wiring devices other than general purpose outlets & general lighting switches.

**END OF SECTION**

## **Section 16180**

### **Metal Framing**

**SECTION 16180****METAL FRAMING****PART 1 - GENERAL****1.1 Related Documents**

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

**1.2 Summary**

This section specifies the furnishing and installation of metal framing, including channels, fittings, clamps, hardware, electrical accessories and brackets.

**1.3 Submittals**

Submit manufacturer's literature and product data & sample.

**PART 2 - PRODUCTS****2.1 Materials**

1. Make channels, fittings, clamps, electrical accessories and brackets of sheet steel or of malleable cast iron. Fabricate threaded fasteners of carbon steel.

**2.2 Coatings**

1. Galvanizing: Hot-dip galvanize all steel components.
2. PVC. At the factory, apply a minimum 10-mil-thick PVC coating, bonded to metal.
3. Electroplating. Electroplate threaded steel fasteners with cadmium.

**2.3 Sizes**

Provide channels fabricated from not less than 12-gauge sheet steel, 40mm wide and not less than 40mm deep.

**PART 3 - EXECUTION****3.1 Application**

Use hot-dipped galvanized steel components in all areas. Use PVC-coated components when exposed to the weather or when located in a corrosive atmosphere.

**3.2 Supports**

Provide metal framing to support large or heavy wall-mounted equipment, wall-mounted raceways and ceiling-hung raceways.

**3.3 Anchor Bolts**

Use 12-mm diameter by 75mm long expansion bolts to attach framing to concrete. Space bolts a maximum of 65cm on center, with not less than two bolts per piece of framing.

**3.4 Touch-up**

Touch up all scratches or cuts on steel components with an approved zinc chromate or a 90 percent zinc paint. Use a PVC compound on PVC-coated components.

**END OF SECTION**

**Section 16190**

**Supporting Devices**



**SECTION 16190**  
**SUPPORTING DEVICES**

**PART 1 GENERAL****1.01 Work included:**

- A. Conduit supports
- B. Cable tray supports
- C. Trunking supports

**1.02 Related Work:**

- A. Raceway 16110
- B. Cable Tray 16114

**1.03 Submittals:**

Submit manufacturer's literature, dimensioned drawings and installation instructions.

**PART 2 PRODUCTS****2.01 Conduit Supports:**

- A. Single Runs: Surface:- galvanized spacer saddles or ring bolt type hangers with special spring clips.  
  
Flush : - galvanized pipe hooks or similar for walls and saddles for partition walls.
- B. Multiple Runs: Horizontal: conduit rack with 25 percent spare capacity.
- C. Vertical Runs: Channel support with conduit fittings and 25 percent spare capacity.

**2.02 Cable Tray and Trunking Supports:**

- A. Trapeze style hangers 41 x 41 mm galvanized steel channels, supported by 10 mm galvanized steel threaded rod from preset threaded concrete inserts or galvanized cantilever brackets on H section support frames, 38 mm x 38 mm, 12 gauge, or heavier capable of supporting weights of assembly plus 20 kg.

**2.03 Anchor Methods:**

- A. Hollow wall : Toggle bolts or spider type expansion anchors.
- B. Solid wall : Lead expansion anchors or preset inserts.
- C. Metal surface : Machine screw, bolts or welded studs.
- D. Wood surfaces : Wood screws.
- E. Concrete surfaces : Self-drilling anchors or power-driven studs.

**PART 3 EXECUTION**

- A. Layout to maintain headroom, neat mechanical appearance, consistent with the architectural treatment in the location.
- B. Install cable tray and trunking supports at 3 m on centers and at all bends and tee fittings.
- C. Ensure there is no conflict with other services.
- D. Conduit or cable straps shall not be welded to steel structures.
- E. Each conduit shall be supported within 300 mm of junction boxes and fittings. Conduit support shall be entirely independent of these boxes and fittings.
- F. Maximum spacing of conduit supports shall be 3m on center.

**END OF SECTION**

## **Section 16411**

### **Power-Factor-Correction Capacitors**

**SECTION 16411****POWER-FACTOR-CORRECTION CAPACITORS****PART 1 GENERAL****1.1 Related Documents**

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

**1.2 Summary**

- A. This Section includes power-factor-correction equipment.
- B. This Section includes automatic power-factor-correction units and capacitor equipment.

**1.3 Submittals**

- A. Product Data: For each type of product specified. Include data on features, components, ratings, and performance. Include dimensioned plan and elevation views of enclosures and details of control panels. Show access and workspace requirements.
- B. Shop Drawings: From manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Wiring Diagrams: Detail internal and interconnecting wiring and differentiate between manufacturer-installed and field-installed wiring.
- C. Product Certificates: Signed by manufacturers of products certifying that the products furnished comply with requirements.
- D. Factory Test Reports: Evidence of product's compliance with specified requirements.
- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements for tests specified in Part 3.
- F. Maintenance Data: For equipment to include in the maintenance manuals specified in Division 1 include the following:
  - 1. Lists of spare parts and replacement components recommended for storage at the Project site for ready access.

**1.3. Submittals (cont'd)**

2. Detailed operating instructions covering operation under both normal and abnormal conditions.
3. Include cell and fuse replacement instructions.

**1.4 Quality Assurance**

- A. Comply with NEMA CP 1 and IEEE 18.
- B. Comply with NFPA 70.
- C. Listing and Labeling: Provide power-factor-correction equipment specified in this Section that is listed and labeled.
  1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

**1.5 Warranty**

- A. General Warranty: Special warranties specified in this Article shall not deprive the Employer of other rights the Employer may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
- B. Special Warranty for Capacitor Cells: A written warranty, signed by manufacturer and principal Installer, agreeing to replace capacitor cells that fail in materials or workmanship within the specified warranty period.
- C. Warranty Period: 3 years from date of Substantial Completion.

**PART 2 - PRODUCTS****2.1 Manufacturers**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Westinghouse/JTE.
  - b. General Electric Co.
  - c. Square D Co.  
or equal and approved alternative.

## 2.2 Capacitors, General

- A. Construction: Multiple capacitor cells or elements factory wired in 3-phase groups and mounted in metal enclosures.
- B. Capacitor Cells: Dry metallized-dielectric, self-healing type. Each cell is encapsulated in thermosetting resin inside a plastic container.
- C. Cell Rupture Protection: Pressure-sensitive interrupter for each cell.
- D. Capacitor Bank MCCB fuse links: Current-limiting, noninterchangeable type, factory installed in each phase and located within the equipment enclosure. Features include the following:
  - 1. Interrupting Capacity: 100,000 A, minimum.
  - 2. Ratings and Characteristics: As recommended by capacitor manufacturer.
  - 3. Neon lamp for each fuse. Connect to illuminate when fuse has opened, and locate so it is visible from outside the enclosure.
- E. Enclosure: NEMA 250, steel or aluminum, arranged to contain the fluid leakage from capacitor cells. Factory equip with mounting brackets suitable for type of mounting indicated. Enclosure types are as follows:
  - 1. Indoor Enclosures: NEMA 250, Type 12.

## 2.3 Fixed Capacitors

- A. Description: Integrally fused.
- B. Discharge Resistors: Factory installed and wired including resistors.
- C. Internal Wiring: Factory wired, ready for field connection to external circuits at a single set of pressure terminals.

## 2.4 Automatic Power-factor-correction Units

- A. Comply with NEMA ICS 2.
  - 1. Description: Factory installed in its own enclosure where indicated one electrical, one line diagram and connected to power circuits as indicated. Units include a separately mounted current transformer to sense current in the power circuit and to provide input to the unit controls.
- B. Configuration: System includes integrally mounted, factory-wired major components including the following:
  - 1. Multiple-MCCB Fuse links.
  - 2. Multiple contactors.
  - 3. Controls.

**2.4 Automatic Power-factor-correction Units (cont'd)**

4. Power-factor meter.
  5. Blown-fuse indicators.
  6. Main circuit breaker.
- C. Performance Requirements: Controls permit operator to select a target power factor adjustable to any value between unity and 0.80 lagging. Controls continuously sense the power factor on the circuit being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contactor to switch a capacitor bank into or out of the circuit. Contactors are opened or closed as required to bring the corrected circuit power factor closer to the target setting. Switch only one capacitor bank at a time.
- D. Solid-state, microprocessor-based controls include an undervoltage relay that interrupts capacitor switching for power supply interruptions longer than 15 ms. "Advance" and "Retard" push buttons on the control panel permit manual sequencing of capacitor switching.
- E. Three-Pole, **600-V** Contactors: Rated for the repetitive high-inrush-switching duty presented by the capacitor loading.
- F. MCCB Fuse links for Protection of Capacitor Banks: Rated to protect contactor, interconnecting wiring, and capacitors.
- G. Air-Core-Type Inductors: Installed in capacitor circuits where required to limit switching surges to within contactor ratings. Inductors are mechanically braced to withstand the maximum fault current to which they may be exposed.
1. LED indicating lights designate energized capacitor banks.
  2. Plated copper, braced to withstand the maximum fault current to which it may be exposed.
- H. Enclosure Access: Hinged door with hand-operated catch. Door is interlocked with controls or main circuit breaker to de-energize capacitors when door is opened.
- I. Standard cubicle doors to allow access to components. Door interlock prevents access while capacitors are energized.
- J. Current Transformer: Type and configuration to suit sensing and mounting conditions indicated.
- K. Power-Factor Meter: Switchboard type, mounted in the enclosure door, with 0.5 lagging to 0.5 leading scale and accuracy of plus or minus 1 percent.
- L. Main Circuit Breaker: Operable from outside the enclosure to disconnect the unit with an operating handle that can be padlocked.

**2.4 Automatic Power-factor-correction Units (cont'd)**

- M. Control Relays: Multi-stage Automatic type with two (2) spare stage for future banks additions. Include a loss of voltage re-setting device with integrally mounted on/off selector switch.
- N. Coordination: Coordination should be run with the main and sub-main switchboards manufacturer regarding interface components required.

**2.5 Factory Finish**

- A. Manufacturer's applied enamel over corrosion-resistant treatment or primer coat.

**2.6 Source Quality Control**

- A. Factory test power-factor-correction equipment before shipment. Comply with NEMA CP 1. Include the following:
  - 1. Routine capacitor production tests, including short-time overvoltage, capacitance, leak, and dissipation-factor tests.
  - 2. Functional test of all operations, controls, indicators, sensors, and protective devices.

**PART 3 - EXECUTION****3.1 Installation**

- A. Install freestanding equipment on concrete housekeeping pad.
- B. Maintain minimum workspace according to manufacturer's written instructions.

**3.2 Identification**

- A. Identify components according to Division 16 Section "Electrical Identification."

**3.3 Field Quality Control**

- A. Inspections and Tests: Inspect and test component features, functions, operations, and protective devices according to manufacturer's written instructions and NETA ATS.
  - 1. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.



**3.3 Field Quality Control**

- B. Adjust system for optimum automatic power-factor correction.

**3.4 Cleaning**

- A. On completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

**3.5 Demonstration**

- A. Training: Engage a factory-authorized service representative to demonstrate adjustment, operation, and maintenance of automatic power-factor-correction unit and to train Employer's maintenance personnel. Demonstrate method of determining optimum settings for system controls.
- B. Conduct a minimum of 2 hours' training.
- C. Schedule training and adjustment with Employer with at least 7 days' advance notice.

**END OF SECTION**

## **Section 16440**

### **Switch Boards- 600Volt and Below**

**SECTION 16440****SWITCHBOARDS - 600 VOLT AND BELOW****PART 1 - GENERAL****1.1 Related Documents**

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

**1.2 Summary**

This section specifies the furnishing and installation of low voltage switchboards.

**1.3 Reference Standards**

- A. NEMA AB1 - Molded Case Circuit Breakers.
- B. NEMA KS1 - Enclosed Switches.
- C. NEMA KS2 - Bolted Pressure Contact Switches.
- D. NEMA PB1.2 - Application Guide for Ground Fault Protective Devices for Equipment.
- E. NEMA PB2 - Dead-Front Distribution Switchboards.
- F. NEMA SG3 - Low Voltage Power Circuit Breakers.
- G. NEMA SG5 - Power Switchgear Assemblies.
- H. ANSI C37.13 - Low-Voltage AC Power Circuit Breakers.
- I. ANSI C37.13a - Low-Voltage AC Integrally Fused Power Circuit Breakers.
- J. ANSI C37.16 - Preferred Rating for Low-Voltage Power Circuit Breakers.
- K. ANSI C37.20 - Switchgear Assemblies Including Metal-Enclosed Bus.
- L. UL 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures.
- M. UL 891 - Switchboards and Switchboard Unit Substations.
- N. UL 977 - Fused Power Circuit Devices.

**1.4 Applicable Provision**

Refer to Section 16010, Electrical General Provisions.

**1.5 Submittals**

1. Brochures: Submit brochures on the switchboard, main protective device, branch circuit protective devices and instrumentation.
2. Dimensional Drawings: Submit dimensional drawings of the switchboard, including top and bottom views showing entry and exit space for trenches conduits and busways, front and side elevations showing arrangement of all devices and also include dimensional data on all buses including material type and capacity of the buses.
3. Electrical Information: Submit one line diagrams for equipment being provided. Also submit information on all protective devices including type, ratings and settings of all trips provided.

**PART 2 - PRODUCTS****2.1 Description**

4. General: Provide a completely factory assembled switchboard category 2B from incoming line lugs to load terminals of all branch protective devices. Include all necessary buses, supports, devices and provisions for future connections as shown on plans.
5. Size: The physical size and configuration of the switchboard and equipment may be varied to suit the manufacturer's standard design, provided the intended functions are accomplished. Any change in size or configuration must be so noted on the submittal.

**2.2 Ratings**

1. Voltage Characteristics: 400/230, Three phase, Four wire, 50 hertz.
2. Main Bus: as indicated on drawings.
3. Available Short Circuit Current. As indicated on the drawings.
4. Device Ratings. As indicated on the drawings.

## 2.3 Enclosure

1. Construction.
  - a. Fabricate the switchboard enclosure with the required number of vertical sections nominally 230cm high and with width and depth as shown on drawings. Bolt vertical sections together to provide a rigid, freestanding, metal-enclosed unit which must withstand all shipping, handling and installation procedures without damage or deformation.
  - b. Completely enclose the frame with removable, bolted, code-gauge sheet steel covered panels and hinged doors. Form all coverplates and doors to eliminate sharp edges.
2. Access.
  - a. Provide an assembly which permits access to buses and devices for installation and future maintenance from the front and rear.
  - b. Provide adequate wiring gutter space at top, bottom and sides for easy access to all wiring terminations.
3. Device Mounting.
  - a. Provide a unit with individually mounted main circuit breaker and group mounted branch circuit breakers.
  - b. Assembly must permit interchanging devices of the same type, rating and method of operation.
4. Lifting Provisions.
  - a. Provide permanent lifting means on top of shipping sections.
  - b. Include an integral roll-along lifting device for switchboards equipped with draw-out devices. Mount lifting device on top of switchboard.
5. Finish: Grind all steel surfaces smooth, with all burrs, sharp edges, welding splatters, loose rust, scale and the like totally removed after fabrication. Following this, chemically clean and treat steel work to allow a good bond between the steel surfaces and apply a rust-preventive primer paint. After priming, thoroughly paint the inside and outside with a suitable finish paint. Supply 1 pint of finish paint for each switchboard for touch-up after installation.

## 2.4 Buss

1. Main, Section and Branch Bus.
  - a. Material: Fabricate all buses of 98% IACS conductivity, tin- or silver-plated copper with rounded edges. Make all connections using a minimum of two bolts.
  - b. Design:
    1. Rate main bus for currents as indicated on drawings:
    2. Determine current rating for section bus and branch bus on the basis of service to all devices including spares and spaces for future addition. Size section bus a minimum of 60% of the main bus rating.
    3. Size all buses to limit their temperature rise within the switchboard to 65EC based on a 40EC outside ambient temperature.
    4. Size all buses so that current density will not exceed 1000 amperes per square inch.
    5. Have each individual phase bus bar insulated to withstand 2000 volts a-c for 1 minute.
  - c. Neutral Bus: In each switchboard section include an uninsulated neutral bus on insulated bus supports secured to the section frame and bolt to neutral bus bars in adjacent sections, thus providing a continuous neutral bus.
  - d. Ground Bus: In each switchboard section, include an uninsulated copper ground bus bar for the equipment. Secure the bar to the unit frame and bolt to the ground bus bars in adjacent sections, thus providing a continuous equipment ground bus. Arrange the equipment ground bus to ground the switchboard parts which do not carry current. Include terminations at the bus bar for feeder and branch circuit grounding conductors. The terminations must be exothermically welded on or be of an approved pressure connector type. Make area of ground bus not less than 25mm.
  - e. Length: Extend all buses the entire length of the switchboard. Buses must have the required capacity for their total length. Make provisions for extensions from either end of buses.
  - f. Insulators: Support main, section and branch bus systems with insulators to provide short circuit bracings. Use non-carbonizing, non-tracking insulators.

## **2.5 Device and Bus Isolation**

Isolate vertical buses from each other using insulating barriers. Provide insulating barriers between vertical and main bus and between main bus and load terminal. Include barriers at rear and sides of individually mounted devices. Provide horizontal barriers for complete compartmentalization of individually mounted devices.

## **2.6 Main Protective Device**

1. Type: As the main protective device for the switchboard, provide a 100% rated, 3-pole, low voltage, non-fused power circuit breaker.
2. Operating Mechanism: Stored energy, quick-make, quick-break type.
3. Characteristics.
  - A. Mounting: Draw-out.
  - B. Operation: Electrical.
  - C. Trip: Long time, and short time and instantaneous, with settings as indicated on the drawings.
4. Accessories.
  - A. Integral ground fault protection.
  - B. Ground fault indicating target.
  - C. Mechanical pushbutton trip and indicator.
  - D. Provisions for padlocking in the open position.
5. Acceptable Manufacturers: General Electric, ABB, Westinghouse Square D.

## **2.7 Branch Circuit Protective Devices**

1. Type: As branch circuit protective devices, provide 100% rated, 3-pole, molded case circuit breakers.
2. Operating Mechanism: Quick-make, quick-break, over-center switching mechanism.

**2.7 Branch Circuit Protective Devices (cont'd)**

3. Characteristics.
  - A. Mounting: Stationary with bolted connections.
  - B. Operation: Manual.
  - C. Frame Size: As indicated on drawings.
  - D. Trip: Long time, short time and instantaneous with settings as indicated on the drawings.
4. Accessories.
  - A. Mechanical pushbutton trip and indicator.
  - B. Provisions for padlocking in the open position.
5. Acceptable Manufacturers. General Electric, ABB, Westinghouse, Square D.

**2.8 Metering**

1. Meters: Equip the switchboard with ammeters and voltmeters. Provide meters for semi-flush mounting, and minimum size 10 cm square. Use ammeters with 2% accuracy and 250-degree indicating scale. Provide meters such as General Electric Type AB-40, Westinghouse KA-241 or approved equal.
2. Switches and Transformers: Provide rotary meter switches, current transformers and potential transformers as required. Use General Electric Type M, Westinghouse Type W-2 or approved equal.
  - A. Provide ammeter rotary switch with positions 1, 2, 3 and OFF.
  - B. Provide voltmeter selector switch with positions 1-2, 2-3, 3-1, 1-N, 2-N, 3-N and OFF.

**2.9 Control Wiring**

For switchboard control wiring provide 600-volt, Type TBS or SIS wire. Install all control wiring complete at the factory, neatly bundled to protect it from mechanical damage.



## 2.10 Identification

1. Nameplates: To identify switches, breakers, and other major devices, provide engraved phenolic nameplates with black characters on a white background. Engrave the nameplates with characters a minimum of 5mm high. Mount nameplates on the front of door or panels adjacent to the device, and secure with screws.
2. Legend: Indicate on the nameplate legend the name of the circuit, panelboard, motor control center or equipment served by the device.
3. Mimic Device: Provide a plastic strip mimic bus on the front of the switchboard. Use symbols similar to a one-line diagram. Secure mimic bus with screws.

## 2.11 Ground Fault Protection

1. Description: Provide ground fault protection on main circuit breaker devices. The unit shall include coordinated current sensors, solid state relay and monitor of the same manufacturer.
2. Current Sensors: Provide a zero sequence type current transformer around all phase and neutral conductors.
3. Solid State Relays: Provide solid state relays which are adjustable from 100 to 1200 amperes, and from instantaneous to one second time delay by means of lockable, direct indicating knobs on the front of the unit.
4. Monitor Panel: Provide a monitor panel mounted on front of the switchboard which shall include the following:
  1. Red light to indicate a ground fault function has occurred.
  2. "Reset" pushbutton.
  3. "Test" pushbutton.
  4. "Control Power On" pilot light.
5. Testing: The switchboard manufacturer shall test the ground fault system at the factory and shall verify tripping of the ground fault relays. This test shall not involve operating the push-to-test button, but shall involve passing a primary current through the current sensor and measuring the time required for the relay to trip the associated device. Any relay which will not track the published characteristic curves shall be replaced with one that is accurate.

**2.12 Listing**

The switchboard shall be U.L. listed as suitable for use as service entrance equipment.

**2.13 Undervoltage and Reverse Phase Protection**

Provide a Westinghouse CVQ or General Electric ICR relay which provides both undervoltage and reverse phase (100% negative sequence) protection where indicated on the drawings.

**2.14 Manufacturers**

Acceptable manufacturers are General Electric, ABB, Square D and Westinghouse.

**PART3 - EXECUTION****3.1 Protection of Switch board**

See Section 16010, paragraph 3.1 - Electrical General Provisions.

**3.2 Foundation Pad**

Provide a foundation pad for the switchboard as specified in Section 16010, A Electrical General Provisions. Secure the switchboard to the pad as recommended by the manufacturer. Include openings for bottom feeds to the switchboard which are compatible with the equipment provided.

**3.3 Equipment Installation**

6. Field Connections: Make field connections of buses between switchboard sections with splice bus and hardware provided by the switchboard manufacturer.
7. Equipment Settings: Properly set adjustable current and voltage settings as noted on shop drawing submittals. Effectively accomplish grounding and bonding.
8. Restoration: Restore all damaged surfaces to factory finish.
9. Inspection: Thoroughly inspect the switchboard for items such as loose connections and presence of foreign materials and remedy prior to energizing the switchboard. All bolted connections shall be torqued to the manufacturer's recommendations.
10. Double Lugging: Double lugging on one protected device to feed two separate loads will not be permitted.

### **3.4 Testing**

1. After installation and before acceptance by the Engineer, the Contractor shall test all ground fault relays in accordance with NEC paragraph 230-95. This test shall involve passing a primary current through the current sensor with a suitable, low voltage test set and timer, which shall allow verification that the ground fault relays track their published curves and that they actually trip the devices on which they are applied. This test shall also include the polarity of the current sensors and give an indication of satisfactory operation of voltmeters, ammeters and their selector switches.
2. The Contractor shall notify the Engineer of this test date 7 days in advance so the tests can be properly witnessed.

**END OF SECTION**

## **Section 16455**

### **Motor Starters- 600 Volt & Below**

**SECTION 16455****MOTOR STARTERS - 600 VOLT & BELOW****PART 1 - GENERAL****1.1 Related Documents**

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

**1.2 Summary**

This section specifies the furnishing and installation of individual motor starters rated 600 volts and below.

**1.3 Reference Standards**

1. ANSI C19 - Industrial Control Apparatus.
2. NEMA ICS - Industrial Controls and Systems.
3. UL 508 - Industrial Control Equipment.

**1.4 Applicable Provisions**

Refer to Section 16010, Electrical General Provisions.

**1.5 Submittals**

Submit Shop drawings and product data for each component.

**PART 2 - PRODUCTS****2.1 Magnetic Motor Starter**

1. Type: Provide magnetic, full-voltage, non-reversing motor starters, unless otherwise indicated.
2. Overload Relays: Provide an ambient-compensated thermal overload relay in each phase leg.

**2.1 Magnetic Motor Starter (cont'd)**

3. Contactor: Size contactors according to NEMA standards or as shown. Provide main pole in each phase leg, the number and type of auxiliary contacts to perform the required functions, and two spare auxiliary contacts, one normally open and one normally closed. Use double break contacts of silver-cadmium oxide or similar material to minimize sticking or welding. Provide contactor coils suitable for continuous operation at 230 volts, 50 hertz.
4. Control Power Transformer.
  1. Voltage: Provide in each enclosure a single-phase control power transformer with a 400-volt primary and a 230-volt secondary.
  2. Fuses: Fuse both primary lines of the transformer and connect to Line 1 and Line 2. Fuse the secondary line leaving transformer terminal X1. Ground the line leaving terminal X2. Use rejection-type fuse clips and RK-1 type current limiting fuses on the primaries. Coordinate primary fuses with secondary fuse to clear a faulted transformer but not blow on magnetizing inrush current.
  3. Size: Provide manufacturer's standard size transformer, unless noted otherwise on the drawings.
5. Enclosure: Provide a IP-42 enclosure, unless otherwise indicated on drawings.
4. Control Devices: Provide control devices on the front of the enclosure, as follows:
  1. Selector Switches: Heavy-duty, oil-tight, maintained contact, 3- position, with marked nameplate HAND-OFF-AUTOMATIC, unless other-wise indicated.
  2. Pushbuttons: Heavy-duty, oil-tight, momentary contact with marked nameplate START-STOP, unless otherwise indicated.
  3. Indicating Lights: Pilot light assemblies shall be heavy-duty, oil-tight transformer type with rated life of 20,000 hours. Neon lamps are not acceptable. Provide red (running) and green (stopped) lenses. On two-speed starters, provide amber (low speed), red (high speed) and green (stopped) lenses.

## **2.2 Combination Switch-starter**

1. Type: Provide combination disconnect switch and magnetic motor starter, as indicated on the drawings.
2. Switch: Heavy-duty, quick-make and quick-break. Provide fused or un-fused type as indicated on the drawings. Make provisions for padlocking in the open position.
3. Fuse Clips: Provide rejection-type fuse clips.
4. Starter: Provide magnetic motor starter as specified in paragraph 2.1.
5. Enclosure: Provide an IP42 enclosure, unless otherwise indicated on drawings.
6. Fuses: Provide fuses conforming to Fuses - 600 Volt and below.

## **2.3 Manual Motor Starters**

Provide line voltage manual motor starters for single-phase motors, as indicated on the drawings. Include bimetallic thermal overload protection in each ungrounded phase leg. Provide the toggle-operated starter in a NEMA 1 enclosure, unless otherwise indicated.

## **2.4 Acceptable Manufacturers**

Acceptable manufacturers are ABB, General Electric, ITE, Square D, Westinghouse.

# **PART 3 - EXECUTION**

## **3.1 Installation**

1. Install units where indicated on the drawings. In general, mount combination units so that operating handle is approximately 150cm above finished floor. On non-combination units, mount so that control device is approximately 120cm above finished floor. Where grouped, align tops of units.

## **3.2 Overload Settings**

Set overload relays at maximum values permitted by NEC 430-32, based on actual installed motor nameplate full load amperes.

**END OF SECTION**

**Section 16470**

**Panelboards- Distribution & Branch Circuit**



**SECTION 16470****PANELBOARDS - DISTRIBUTION & BRANCH CIRCUIT****PART 1 - GENERAL****1.1 Related Documents**

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

**1.2 Summary**

This section specifies the furnishing and installation of distribution and branch circuit panelboards.

**1.3 Reference Standards**

1. ANSI/UL 50 - Cabinets and Boxes.
2. ANSI/UL 67 - Electric Panelboards.
3. NEMA AB 3 - Molded Case Circuit Breakers and Their Application.
4. NEMA PB 1 - General Instructions for Proper Handling, Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

**1.4 Submittals**

1. Provide product data on panelboards and circuit breakers.
2. Provide shop drawings with a schedule for each panelboard which indicates the circuit breaker arrangement and other pertinent features. Panelboard schedules must be identical to the schedules in the project documents, unless there is a technical reason which requires a deviation. Submitted panelboard schedules must also contain confirmation of panelboard characteristics.

**PART 2 - PRODUCTS****2.1 Enclosure**

1. Cabinet: Construct cabinets in accordance with UL 50. Use not less than 16-gauge galvanized sheet steel. Provide a minimum 4-inch gutter wiring space on each side. Reinforce cabinets and securely support bus bars and overcurrent devices to prevent vibration and breakage in handling. Provide cabinets without conduit knockouts. All conduit knockouts shall be made in the field. Surface-mounted panelboards in finished spaces shall have cabinet finishes to match doors and trim as specified below. In unfinished areas such as mechanical and electrical rooms, galvanized sheet steel cabinets are sufficient, provided galvanizing occurs after components are cut or sheared.
2. Doors and Trim: Fabricate doors and trim of cold-rolled sheet steel. Equip doors with flush-type combination catch and key lock. Key all locks alike. Fasten trim for panelboards to cabinets by an approved means which permits both horizontal and vertical adjustment. Trim for surface-mounted panelboards must fit the cabinet with no overhang. Apply a finish to trim and doors consisting of two coats of enamel over a rust-inhibiting prime coat.

**2.2 Bus**

1. Fabricate phase, neutral and ground buses of 98% IACS conductivity copper with rounded edges. Size bars as indicated and brace them to withstand symmetrical short circuit current as indicated on drawings. Install buses in allotted spaces so that devices can be added without additional machining, drilling or tapping. Use buses with silver-plated contact surfaces. Include copper neutral bus rated not less than the phase bus ampacity. Include copper ground bus rated not less than 50 percent of main bus ampacity.

**2.3 Magnetic Motor Starter**

Provide circuit breakers for the specified service with the number of poles and ampere ratings indicated.

1. Provide breakers which are quick-make and quick-break on both manual and automatic operation. Use a trip-free breaker which is trip indicating. Incorporate inverse time characteristic by bimetallic overload elements and instantaneous characteristic by magnetic trip.
2. For multi-Pole and 3-pole breakers, use the common-trip type so that an overload or fault on one pole will trip all poles simultaneously. Handle ties are not acceptable.
3. Unless otherwise indicated, provide circuit breakers with the minimum following interrupting ratings:
  1. 10,000 rms symmetrical amperes at rated voltage.

**2.3 Magnetic Motor Starter (cont'd)**

4. Connect breakers to the main bus by means of a solidly bolted connection. Use breakers which are interchangeable, capable of being operated in any position within the panel. Independently mount breakers so that a single unit can be removed from the front of the panel without disturbing or removing main bus, other units or other branch circuit connections.
5. Cable lugs shall be copper or bronze.

**2.4 Circuit Identification**

For each panelboard, provide a steel directory frame mounted inside the door with a heat-resistant transparent face and a directory card for identifying the loads served. Type directory as specified in Section 16010.

**2.5 Listong**

1. UL 67 - Electric Panelboards.

**2.6 Acceptable Manufacturers**

Acceptable manufacturers are GE Company, Square D Company, Westinghouse, ABB.

**PART 3 - EXECUTION****3.1 Installation**

Install panelboards in the locations as shown on plans.

**3.2 Mounting Height**

- A. Install the panelboards such that the center of the switch or circuit breaker in the highest position will not be more than 210cm above the floor or working platform.

**3.3 Protection**

1. Permanent Doors and Trim. Permanent doors and trim shall be installed immediately before panelboards are energized. Permanent doors and trim shall be maintained in factory condition after installation. Doors shall remain closed at all times except when the panelboard is de-energized and work is taking place within the panelboard.

**3.3 Protection (cont'd)**

2. Cabinets: Cabinet interiors shall be maintained "white glove" clean at all times. Cabinet exteriors shall be maintained free of mud, spray-on insulation, paint spray, and all substances not placed on the exterior surface by the panelboard manufacturer.

**END OF SECTION**

## **Section 16490**

### **Enclosed Safety Switches**

**SECTION 16490****ENCLOSED SAFETY SWITCHES****PART 1 - GENERAL****1.1 Related Documents**

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

**1.2 Summary**

This section specifies the furnishing and installation of enclosed safety switches.

**1.3 Reference Standards**

1. ANSI/UL 98 - Enclosed and Dead-Front Switches.
2. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches.

**1.4 Applicable Provisions**

Refer to Section 16010, Electrical General Provisions.

**1.5 Submittals**

Provide shop drawings and manufacturers product data on each type and rating of switch.

**PART 2 - PRODUCTS****2.1 Characteristics**

1. Voltage: Provide switches with a voltage rating of 600 volts a-c, as required for the installed system voltage.
2. Type: Provide switches conforming to NEMA KS 1 standard for Type HD (heavy duty).
3. Contacts: Provide switches with quick-make, quick-break contacts.
4. Poles. As indicated on plans.

## 2.2 Construction

1. Enclosure: Provide IP-42 switch enclosures for indoor dry locations and IP-55 for outdoor locations unless otherwise shown.
2. Operating Handle: Provide a handle suitable for padlocking in the OFF position with as many as three padlocks of 8mm diameter shank. Use a defeatable, front accessible, coin-proof door interlock to prevent opening the door when the switch is in the ON position and to prevent turning the switch ON when the door is open.
3. Terminal Shield: Provide incoming line terminals with an insulated shield so that no live parts are exposed when the door is open.
4. Neutral: Provide each switch with an isolated, fully rated neutral block. Make provisions for bonding the block to the enclosure.
5. Ground: Provide each switch with a ground lug.
6. Fuse Holders: Where fusible switches are shown, provide switches with rejection-type fuse holders which are suitable for use with fuses specified under specifications Section, Fuses - 600 Volt and Below.
7. Nameplates: Provide metal nameplates, front cover mounted, that indicates the switch type, catalog number and horsepower rating (with both standard and time delay fuses).

## 2.3 Listing

UL 98 - Safety Standard for Enclosed Switches.

## 2.4 Acceptable Manufacturers

Acceptable manufacturers are:-

- GE Company.
  - Square D Company.
  - Westinghouse.
  - ABB.
- or equal and approved alternative

## PART 3 - EXECUTION

Install switches where indicated on drawings. In general, mount so that operating handle is approximately 150cm above finished floor. Where grouped, align tops of switches.

**END OF SECTION**