

SECTION 16122**600 VOLT CABLE****PART 1 GENERAL****1.01 SUMMARY**

- A. Single and multi core insulated power conductors rated 600 volts, sized larger than 10 mm².

1.02 RELATED WORK

- A. Grounding and Bonding Section
- B. Wiring Section
- C. Equipment Identification Section

1.03 REFERENCE STANDARDS

- A. B.S. 6360, 6004, 6207, 6476, 6346, 5468
- B. IEC 228, 287, 502

1.04 SUBMITTALS

- A. Provide Product Data and manufacturers literature
- B. Provide Operation and Maintenance Data
- C. Submit blank test sheets for approval
- D. Submit completed factory any site test sheets
- E. Sample of cable pulling lubricant

PART 2 - PRODUCTS**2.01 GENERAL**

- A. Cables shall be one, three or four core consisting of 99% conductivity, bare annealed stranded copper conductors rated at a normal maximum operating temperature of 90 degrees C.
- B. Insulation for cables longer than 10 mm² shall be of extruded semi-conducting cross-linked polyethylene, meeting standards requirements. A semi-conducting tape may be used under the polyethylene.
- C. Provide a PVC overall jacket on all cables, with a durable marking on the surface of the jacket at intervals not exceeding 610mm. marking shall include manufacturers name, conductor size and voltage class of cable.
- D. Cable ampacity and electrical characteristics shall conform with specified codes and standards.

- E. Provide a ground wire with each circuit sized in accordance with the grounding specification section. Ground wire shall be bare, concentric lay copper.
- F. Where armoring is required, it shall be steel strip armour on single core cables and galvanized steel or tape armour on multi-core cables.

2.02 SPLICES AND TERMINATION

- A. Cable splices and terminations shall be furnished in kit form and shall conform to the recommendations of the cable manufacturer. All material shall be furnished in factory sealed packages and shall not be opened until required for use.
- B. Splices shall be suitable for installation in manholes
- C. Terminal connectors shall be pressure; bolted clamp type or compression type.

2.03 CABLE TIES AND CABLE MARKERS

- A. Lacing material for site installed cable shall be non-releasing nylon ties.
- B. Tie-on cable markers shall be provided in accordance with the equipment identification specifications section.

2.04 WIRING

- A. Single core 600 volt cable of size 10 mm² and less is specified in the wiring specification section.

2.05 CU/XLPE/SWA/PVC:

- A. To BS 5468, 1000V grade
- B. Conductors : Plain annealed copper to BS 6360
- C. Cables shall comprise plain copper, stranded circular conductors insulated with an adequate thickness of extruded cross linked polythene (XLPE).
- D. Conductors shall be laid up together and wormed circular with suitable pre-formed fillers and wormings, bound with polythene terephthalate (PTP) tape and covered with an extruded PVC sheath minimum 1.4 mm thick.
- E. Multicore cables shall have steel wire or tape armouring, extruded sheath of black PVC.
- F. Single core cables shall be unarmoured, unless otherwise specified, with an extruded black PVC outer sheath.
- G. Outer sheath of single and multicore shall be at least 2.5mm thick.
- H. Design electrical stress at any point in the insulation shall not exceed 3KV per mm.
- I. Conductor screen: non-metallic comprising either:
 - 1- Semi-conducting tape; or
 - 2- A layer of extruded semi-conducting material.

- J. The electro-static screen over insulation shall comprise a non-metallic layer of semi-conducting tape or extruded semi-conducting material applied over the insulation and in direct contact with it, followed by a layer of copper tape applied helically over the semi- conducting layer to ensure close contact throughout.
- K. Prevent void formation in insulation by careful control of its passage through the temperature graded water baths.

PART 3 - EXECUTION

3.01 INTERNAL CABLE INSTALLATION

- A. Support internal horizontal and vertical runs on cable tray using non-ferrous clamps at 1 meter intervals.
- B. Arrange multicore cables to run parallel on tray with a lateral spacing of the diameter of the largest cable.
- C. Arrange single core cables with phases in trefoil formation providing one cable diameter space between trefoil groups.
- D. Where cables are routed through walls or floors, the opening between the cables and the structure shall be sealed such that the fire resistance of the sealing barrier is at least as great as the surrounding structure.

3.02 EXTERNAL CABLE INSTALLATION

- A. Immediately prior to the placement of each cable or cable group, the raceway route to be followed shall be inspected and ascertained to be complete in installation and free of all materials detrimental to the cable or its placement. All cables assigned to a particular duct or conduit shall be grouped and pulled in simultaneously, using cable grips or pulling eyes and acceptable lubricants.

All cables shall be carefully checked both as to size and length before being pulled into conduits or ducts. Cable pulled into the wrong conduit or duct or cut too short to rack, train, and splice as specified herein, shall be removed and replaced.

- B. **Cable in Shafts etc.:** Cable shall be supported at all times without short bends or excessive sags and shall not be permitted to lie on the manhole floor. Cable ends must not be submerged. Cable racks, saddle supports or trays shall be provided for permanent support. Temporary support required during placement shall be with rope slings, timbers, or alternate method acceptable to the Client Engineer.

Cable shall be located in manholes to provide minimum interference with other cables to be installed or installation of future cables in spare conduits.

- C. **Cable Pulling :** Pulling shall be done with nylon or rope recommended by cable manufacturer.

- D. **Cable Grips:** Factory installed pulling eyes shall be used for pulling cable where they are available. Woven wire cable grips shall be used to pull all single conductor cable, 70 mm² and larger, where pulling eyes are not available, and all multi conductor cable. Pulling loops shall be used to pull single conductor cable smaller than 70 mm². When a cable grip or pulling eye is used for pulling, the area of the cable covered by the grip or seal plus 150 mm shall be cut off and discarded when the pull is completed.

As soon as the cable is pulled into place, the pulling eyes, cable grips, or pulling loops shall be removed and any cable which was sealed shall be resealed.

- E. **Inspection:** The outside of each cable reel shall be carefully inspected and protruding nails, fastenings, or other objects which might damage the cable shall be removed. A thorough visual inspection for flaws, breaks, or abrasions in the cable sheath shall be made as the cable leaves the reel, and the pulling speed shall be slow enough to permit this inspection. Damage to the sheath or finish of the cable shall be sufficient cause for rejecting the cable. Cable damaged in any way during installation shall be replaced.
- F. **Pulling Tension:** The pulling tension of any cable shall not exceed the maximum tension recommended by the cable manufacturer. Pulling mechanisms of both the manual and power types used by the Contractor shall have the rated capacity in tones clearly marked on the mechanism. Whenever the capacity of the pulling mechanism exceeds the recommended pulling tension of the cable as given by the cable manufacturer, a dynamometers shall be used to show the tension on the cable and the indicator shall be constantly watched. If any excessive strain develops, the pulling operation shall be stopped at once and the difficulty determined and corrected.
- G. **Sidewall Pressure:** To avoid insulation damage from excessive sidewall pressure at bends in duct and conduit runs, the pulling tension in kilograms at a bend shall not exceed 445 times the radius of the bend in meters.
- H. **Cable Bends:** Extreme care shall be exercised during the placement of all cable to prevent tension and bending conditions in excess of the manufacturer's recommendations. The permanent radius of bend after cable installation shall be in accordance with the cable manufacturer's recommendations.
- I. **Supports:** All cable supports and securing devices shall have bearing surfaces located parallel to the surfaces of the cable sheath and shall be installed to provide adequate support without deformation of the cable jackets or insulation.

Final inspection shall be made after all cable is in place and, where supports, bushings, and end bells deform the cable jacket, additional supports shall be provided. Additional cable protection such as a wrapping of light rubber belting, friction tape, or similar materials shall be provided when required. Cable in vertical runs shall be supported by woven wire grips in accordance with the Code requirements.

- J. **Cable Identification:** The Contractor shall identify all cables in the locations specified in other sections.

- K. **Moisture Seals:** Each cable shall be kept sealed except when termination and splicing work is being performed.

The ends of all cables shall be sealed with heat shrinkable caps. Cap sizes shall be as recommended by the cap manufacturer for the cable outside diameter and insulation. Caps shall contain sufficient adhesive that shrinkage of the cap during application results in formation of a positive watertight seal capable of withstanding complete immersion or total exposure without permitting the entrance of moisture.

Before and after pulling, the leading and seal of each length of cable shall be examined and repaired if necessary. All cut cable ends shall be promptly sealed after cutting except those to be spliced or terminated.

- L. **Crimping Tools:** Crimping tools used to secure conductors in compression type connectors or terminal lugs shall be those made for that purpose and for the conductor sizes involved. The crimping tools shall accurately crimp the conductor insulation support sleeve where provided. Crimping tools shall be provided with guides to position connectors in the crimping, and shall be of a type which prevents the tools from opening until the crimp action is completed. Crimping tools shall be a product approved by the connector manufacturer. The Contractor shall establish and maintain a tool certification program to ensure that crimping tools are kept in accurate operating condition.

- M. **Termination:** Cable shall be terminated in accordance with the following requirements.

- 1- Train cable in place and cut squarely to required length. Avoid sharp bends.
- 2- Install terminals or terminal connectors as required, ensuring a firm metal-to-metal contact.
- 3- Insulate each connection of cable to an insulated conductor (whether cable, bus, or equipment bushing). The insulation shall cover all exposed surfaces of the conductors; the insulation voltage level of the completed termination shall be not less than the insulation voltage level of the connected conductors. Insulation of terminations shall be as specified in the following paragraphs.

- N. **Insulation of Termination in 600 volt Cable:** Terminations which require insulation in cable rated 600 volts or less shall be insulated in accordance with the following requirements:

- 1- All exposed conductor and connector surfaces shall be covered with a minimum of three half-lapped layers of self-vulcanizing rubber insulating tape.
- 2- A minimum of three half-lapped layers of polyvinyl chloride electrical tape shall be applied over the rubber tape. The polyvinyl chloride tape shall extend a minimum of two cable diameters over the cable jacket and a similar distance over other conductor insulation or connector requiring insulation.

3.03 CABLE TESTING

- A. General: All insulated conductors shall be electrically tested before (factory certificate & RSS certificate) and after placement on site where the engineer shall be present.

All circuits shall be tested with the circuit complete except for connections to equipment. all splices, stress cones on shielded cable, and terminal connector attachments shall be complete prior to testing.

Any circuit failing to test satisfactorily shall be replaced or repaired and then retested.

All equipment and labor required for testing shall be provided by the Contractor.

- B. Continuity, Identification, and Short Circuit Tests: All insulated conductors shall be tested for continuity and conductor identification. In addition, all insulated conductors of multi conductor cable shall be tested for short circuits. The Contractor shall furnish portable, battery powered, ring testers, and other test equipment as required to conduct these tests.

Continuity tests shall include all tests necessary to confirm that the conductor being investigated originates and terminates at the locations designated on the drawings.

Short circuit tests shall include all tests necessary to confirm that no conductor of a multi conductor cable is short circuited to another conductor in that cable.

- C. Insulation Tests: Resistance from ground provided by the insulation on all site installed insulated conductors shall be measured. Measurement shall be accomplished as follows.
- D. All 600 volt insulated conductors shall be tested with a 1,000 volt calibrated megger or an equivalent testing device. Insulation resistance measurements shall be made between each conductor and ground and between each conductor and all other conductors of the same circuit. Minimum acceptable resistance values shall be approximately infinite.
- E. Comprehensive insulation test reports have to be submitted and approved by the Client Engineer before energizing.

END OF SECTION

SECTION 16125**GROUNDING****PART 1 - GENERAL****1.01 SUMMARY**

This section specifies the furnishing and installation of grounding and bonding equipment for electrical systems.

1.02 REFERENCE STANDARDS

- A. ANSI/IEEE Std 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
- B. ANSI/UL 467 - Grounding and Bonding Equipment.

PART 2 - PRODUCTS**2.01 GROUND RODS**

- A. Materials. Provide: -mm by 3.05m long, copper-clad, steel grounding electrodes. Supply a rod to which the copper cladding is permanently and inseparably bonded to a high strength steel core.
- B. Listing. UL 467.

2.02 CONNECTIONS

- A. Materials: Unless otherwise noted, for below grade connections provide exothermic welded type. For above grade connections provide copper or bronze lugs or clamps. Where required, provide plated connectors which will not cause electrolytic action between the conductor and the connector.
- B. Listing: UL 467.

2.03 WIRING

- A. Materials: Provide bare conductors for bonding jumpers. Provide 600-volt insulated conductors having a green/yellow-colored insulation for grounding electrode and equipment grounding conductors. Use solid conductors for 4 mm² wire; and stranded for 6 mm² wire and larger.
- B. Listing: UL 83.

2.04 GROUND BUS

- A. Where a field-provided ground bus is required, use round-edge copper bar with 98 percent International Annealed Copper Standard (IACS) conductivity. Size the bus for not less than 25 percent of the cross-sectional area of the related feeder. A minimum size of 6 mm by 50 mm is required.

PART 3 - EXECUTION

3.01 SYSTEM GROUND

- A. **System Neutral:** Isolate neutral from ground at all points in the system.
- B. **Separately Derived Systems:** Ground neutrals of separately derived systems such as generators, telephone systems, etc., in accordance with NEC 250-26.
- C. **Size:** Size the system grounding electrode conductors to comply with NEC Table 250-94, unless shown larger.
- D. **Testing:** Test the completed grounding system. If the resistance of the grounding system is more than 1.5 ohms, add ground rods to attain 1.5 ohms.

3.02 EQUIPMENT GROUND

- A. **Manholes:** Provide a 50 mm² bare stranded copper ground bus in all manholes. Mount bus 30 cm above floor using one-hole pipe straps 1 m on center. Connect bus to ground rod with a No. 50 mm² conductor. Bond all metallic components and electrical grounding conductors to the bus using lugs or clamps.
- B. **Switchgear Rooms:** Provide a ground bus in switchgear room. Mount bus 30 cm above finished floor and 25 mm from wall around perimeter of room. Connect bus by a grounding conductor with a cross-sectional area equivalent to the ground bus to an acceptable grounding electrode as described in NEC Article 250. Connect all noncurrent-carrying metallic parts of electrical equipment in the room to the bus.
- C. **Raceway Systems and Equipment Enclosures.**
 - 1- Ground cabinets, junction boxes, outlet boxes, motors, controllers, raceways, fittings, switchgear, other electrical equipment and metallic enclosures. Ground equipment and enclosures to the continuous-grounded, metallic raceway system in addition to any other specific grounding shown.
 - 2- Provide bonding jumpers and ground wire throughout to ensure electrical continuity of the grounding system.
 - 3- Provide grounding-type insulated bushings for metal conduits 40 mm and larger terminating in equipment enclosures containing a ground bus and connect the bushing to the ground bus.
 - 4- Provide a green/yellow insulated equipment grounding conductor for each feeder and branch circuit.

- D. **Size:** When grounding and bonding conductors are not sized on drawings, size the grounding conductors in accordance with NEC Table 250-95. Size bonding jumper so that minimum cross-sectional area is greater than or equal to that of the equivalent grounding conductor as determined from NEC Table 250-95.

END OF SECTION

SECTION 16130**BOXES****PART 1 - GENERAL****1.01 SUMMARY**

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

1.02 REFERENCE STANDARDS

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

1.03 SUBMITTALS

- A. Provide product data on the following:
 - 1- Floor boxes.
 - 2- Fire-rated poke-through units.

PART 2 - PRODUCTS**2.01 OUTLET BOXES**

- A. **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 4 cm deep by 10 cm square minimum size box.
- B. **Exposed Device Boxes:** Provide FS or FD cast boxes for surface mounting in areas having exposed rigid metal conduit systems. Provide galvanized steel boxes for surface mounting in areas having exposed PVC.
- C. **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 4 cm deep by 10 cm box.
- D. **Masonry Boxes:** Provide galvanized steel, 10 cm deep, masonry boxes for all devices installed in masonry walls.
- E. **Switch Boxes:** Not permitted.
- F. **Listing:** UL 514.

2.02 JUNCTION, PULL AND SPLICE BOXES

- A. **Construction:** Provide galvanized steel boxes conforming to NEC Article 370.
- B. **Interior Spaces:** Provide NEMA 1 type boxes at least 10 cm deep.
- C. **Exterior Spaces:** Provide NEMA 12X type boxes at least 10 cm deep.
- D. **Embedded:** Provide NEMA 12X cast iron type with flush flanged cover when cast in concrete.
- E. **Listing.** UL 514.

2.03 FIRE-RATED POKE-THROUGH UNITS

- A. **Construction:** Through-floor units shall comply with NEC Article 300-21, shall be UL classified for fire and UL listed electrically.
- B. **Fire Rating:** Through-floor units shall be classified with a fire rating of 2 hours in a floor which is 6 cm thick.
- C. **Box and Conduit:** Underfloor junction box and conduit shall be self-supporting without the attachment of an above-floor fitting. The integral fire barrier must incorporate a cold smoke barrier to prevent the passage of smoke when heat is not present. The junction box shall be 12 cm square by 8 cm deep with knockouts to accommodate up to 1-inch conduits. Box and conduit shall be provided with separation barriers for combination power and communication units. Through-floor unit shall allow replacement of original service fittings with different style service fittings of similar or dissimilar service function, including abandonment condition.
- D. **Above-Floor Fittings:** Provide die-cast aluminum above-floor fitting with satin chrome finished cover. Provide a combination power and communication fitting. Power section shall be equipped with a 15-ampere, 220-volt (NEMA 5-15R) receptacle per Section 16140. Communication section shall have a cover plate with a 5/8-inch bushed opening.
- E. **Listings:** UL 514.

PART 3 - EXECUTION

3.01 OUTLET BOXES

- A. **Flush Boxes:** Unless otherwise indicated, mount all outlet boxes flush within 6 mm 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.
- B. **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.
- C. **Mounting Height:** Mounting height of a wall-mounted outlet box means the height from finished floor to horizontal center line of the coverplate. 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.

- D. **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.
- E. **Box Openings:** Provide only the conduit openings necessary to accommodate the conduits at the individual location.

3.02 FLOOR BOXES

- A. Verify locations of all floor boxes with the Employer's representative before installation. Completely envelope floor boxes in concrete except at the top. Increase slab thickness at boxes if required to obtain a minimum of 30 mm of concrete below bottom of box. Adjust covers flush with finished floor.

3.03 JUNCTION AND PULL BOXES

- A. **Installation:** Install boxes as required to facilitate cable installation in raceway systems. Generally provide boxes in conduit runs of more than 30 meters or as required in Section 16110.
- B. **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.

3.04 FIRE-RATED POKE-THROUGH UNITS

- A. **Installation:** Floor slab or deck shall be core-drilled to accept through-floor conduit unit. Install per manufacturer's recommendations.
- B. **Locations:** Verify locations of all poke-through units with the Engineer before installation.

END OF SECTION

SECTION 16140**WIRING DEVICES****PART 1 - GENERAL****1.01 SUMMARY**

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

1.02 REFERENCE STANDARDS

- A. ANSI/UL 20 - General-Use Snap Switches.
- B. ANSI/UL 498 - Attachment Plugs and Receptacles.
- C. ANSI/UL 943 - Ground Fault Circuit Interrupters.
- D. NEMA WD 1 - General Requirements for Wiring Devices.

1.03 SUBMITTALS

- A. Provide product data on wiring devices and plates.

PART 2 - PRODUCTS**2.01 WALL SWITCHES**

- A. **Type.** Quiet type, back and side wired switches as shown.
- B. **Rating.** 20 amperes, 220 volts.
- C. **Listing.** UL 20 and Federal Specification W-S-896.
- D. **Acceptable Manufacturers.** Not Applicable.

2.02 RECEPTACLES

- A. **Type.** Back and side wired receptacles, as shown.
- B. **Rating.** Scheduled on drawings.
- C. **Listing.** UL 498 and Federal Specification W-C-596.
- D. **Acceptable Manufacturers.** Not Applicable.

2.03 DEVICE PLATES

- A. **Finished Spaces.** Smooth high impact thermoplastic device plates (lexan, noryl or nylon).
- B. **Exposed Boxes in Dry Interior Spaces.** Use plates of heavy cadmium-plated sheet steel. Edges of plates must be flush with edges of boxes.

- C. **Other Areas. Use weatherproof device plates.** Provide cast plates with gasketed spring door covers for protection of device.

2.04 DEVICE COLOR

- A. Supply wiring devices in white.

PART 3 - EXECUTION

3.01 DEVICE COORDINATION

- A. 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.

3.02 WALL SWITCHES

- A. **Location.** Set wall switches in a suitable outlet box centered at the height of 110 cm from the floor, except as otherwise shown. Install switch on the strike side of the door as finally hung.
- B. **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.

3.03 RECEPTACLES

- A. Mount receptacles vertically with the ground on top in a suitable steel outlet box centered at the height of 45 cm from the floor or as shown on the drawings. For horizontally mounted receptacles, ground should be on left. The Engineer reserves the right to make any reasonable changes in receptacle locations without change in the contract sum.

3.04 DEVICE PLATES

- A. **Type.** Provide device plates for each outlet of the type required for service and device involved.
- B. **Ganged Devices.** Mount ganged devices under a single, one-piece, device plate.
- C. **Engraving.** Engrave plates with 3mm-high black letters, if designated for engraving.

END OF SECTION

SECTION 16190**METAL FRAMING****PART 1 - GENERAL****1.01 SUMMARY**

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

PART 2 - PRODUCTS**2.01 MATERIALS**

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

2.02 COATINGS

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

2.03 SIZES

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

PART 3 - EXECUTION**3.01 APPLICATION**

- A. 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.

3.02 SUPPORTS

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

3.03 ANCHOR BOLTS

- A. Use 15 mm diameter by 75 mm long expansion bolts to attach framing to concrete. Space bolts a maximum of 60 cm on center, with not less than two bolts per piece of framing.

3.04 TOUCH-UP

- A. 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 16440**SWITCHBOARDS - 600 VOLT AND BELOW****PART 1 - GENERAL****1.01 WORK INCLUDED**

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

1.02 REFERENCE STANDARDS

- A. NEMA AB1 - Molded Case Circuit Breakers.
- B. NEMA KS1 - Enclosed Switches.
- C. NEMA PB1.2 - Application Guide for Ground Fault Protective Devices for Equipment.
- D. NEMA PB2 - Dead-Front Distribution Switchboards.
- E. ANSI C37.20 - Switchgear Assemblies Including Metal-Enclosed Bus.
- F. UL 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures.

1.03 APPLICABLE PROVISIONS

- A. Refer to Section 16010, Electrical General Provisions.

1.04 SUBMITTALS

- A. **Brochures.** Submit brochures on the switchboard, main protective device, branch circuit protective devices and instrumentation.
- B. **Dimensional Drawings.** Submit dimensional drawings of the switchboard, including top and bottom views showing entry and exit space for 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.
- C. **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 to include ground fault relay settings.
- D. **Coordination Curves.** Manufacturer shall provide coordination curves on log-log paper for the main protective device and for the largest branch circuit devices. These curves shall also show the ground fault protective relay.

PART 2 - PRODUCTS

2.01 DESCRIPTION

- A. **General.** Provide a completely factory assembled switchboard 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.
- B. **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. Any changes made are restricted by Section 16010, paragraph 2.1C.

2.02 RATINGS

- A. **Voltage Characteristics.** 400/220V, three phase, 4 wire, 50 hertz.
- B. **Main Bus.** As noted on plans.
- C. **Available Short Circuit Current.** As noted on the drawings.
- D. **Device Ratings.** As indicated on the drawings.

2.03 ENCLOSURE

- A. **Construction.**
 - 1- Fabricate the switchboard enclosure with the required number of vertical sections nominally 230 cm 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.
 - 2- 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.
- B. **Access.**
 - 1- Provide an assembly which permits access to buses and devices for installation and future maintenance from the front and the back.
 - 2- Provide adequate wiring gutter space at top, bottom and sides for easy access to all wiring terminations.
- C. **Device Mounting.**
 - 1- Provide a unit with panel mounted protective devices.
 - 2- Assembly must permit interchanging devices of the same type, rating and method of operation.

D. Lifting Provisions.

- 1- Provide permanent lifting means on top of shipping sections.
- 2- Include an integral roll-along lifting device for switchboards equipped with draw-out devices. Mount lifting device on top of switchboard.

E. 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.

2.04 BUSES**A. Main, Section and Branch Bus.**

- 1- **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.
- 2- **Design.**
 - a. Rate main bus for currents shown.
 - b. 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.
 - c. Size all buses to limit their temperature rise within the switchboard to 65°C based on a 40°C outside ambient temperature.
 - d. Size all buses so that current density will not exceed 1000 amperes per square inch.
 - e. Have each individual phase bus bar insulated to withstand 2000 volts a-c for 1 minute.

B. 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.

C. 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 6.45 square cm.

D. 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.

- E. **Insulators.** Support main, section and branch bus systems with insulators to provide short circuit bracings. Use non-carbonizing, non-tracking insulators.

2.05 DEVICE AND BUS ISOLATION

- A. 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.

2.06 MAIN PROTECTIVE DEVICES

- A. Type. As the main protective device for the switchboard, provide a 3-pole molded case circuit breaker.
- B. Characteristics.
 - 1- Mounting. Stationary with bolted connections.
 - 2- Operation. Manual.
 - 3- Frame Size. As indicated on the drawings.
 - 4- Trip. Thermal magnetic, with settings and interrupting capacity as located on the drawings.
- C. Acceptable Manufacturers. General Electric, ABB, Square D, Westinghouse Or approved equally.

2.07 BRANCH CIRCUIT PROTECTIVE DEVICES

- A. Type. As branch circuit protective devices for the switchboard, provide 100 percent rated, 3-pole, molded case circuit breakers.
- B. Characteristics.
 - 1- Mounting. Stationary with bolted connections.
 - 2- Operation. Manual.
 - 3- Frame Size. As indicated on the drawings.
- C. Acceptable Manufacturers. General Electric, Gould ABB, Square D, Westinghouse or approved equally.

2.08 METERING

- A. **Meters.** Equip the switchboard with ammeters and voltmeters as shown on the drawings. Provide meters for semi-flush mounting, and minimum size 12 cm square. Use ammeters with 2% accuracy and 250-degree indicating scale with ranges as shown on the drawings. Provide meters such as General Electric Type AB-40, Westinghouse KA-241 or approved equal.

B. **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.

1- Provide ammeter rotary switch with positions 1, 2, 3 and OFF.

2- Provide voltmeter selector switch with positions 1-2, 2-3, 3-1, 1-N, 2-N, 3-N and OFF.

2.09 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

A. **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 5 mm high. Mount nameplates on the front of door or panels adjacent to the device, and secure with screws.

B. **Legend.** Indicate on the nameplate legend the name of the circuit, panelboard, motor control center or equipment served by the device.

C. **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 LISTING

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

2.12 UNDERVOLTAGE AND REVERSE PHASE PROTECTION

A. 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.

PART 3 - EXECUTION

3.01 PROTECTION OF SWITCHBOARD

A. See Section 16010, paragraph 3.1 - Electrical General Provisions.

3.02 FOUNDATION PAD

- A. Provide a foundation pad for the switchboard as specified in Section 16010, 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.

3.03 EQUIPMENT INSTALLATION

- A. Field Connections. Make field connections of buses between switchboard sections with splice bus and hardware provided by the switchboard manufacturer.
- B. Equipment Settings. Properly set adjustable current and voltage settings as noted on shop drawing submittals. Effectively accomplish grounding and bonding.
- C. Restoration. Restore all damaged surfaces to factory finish.
- D. 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.
- E. Double Lugging. Double lugging on one protected device to feed two separate loads will not be permitted.

3.04 TESTING

- A. After installation and before acceptance by the Engineer, the Contractor shall perform test which will include the polarity of the current sensors and give an indication of satisfactory operation of voltmeters, ammeters and their selector switches.
- B. The Contractor shall notify the Engineer of this test date 2 days in advance so the tests can be properly witnessed.

END OF SECTION

SECTION 16445**PANEL BOARDS - DISTRIBUTION & BRANCH CIRCUIT****PART 1 - GENERAL****1.01 WORK INCLUDED**

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

1.02 REFERENCE STANDARDS

- A. UL 50 - Cabinets and Boxes.
- B. UL 67 - Electric Panelboards.
- C. NEMA AB 1 - Molded Case Circuit Breakers.
- D. NEMA AB 2 - Procedures for Verifying the Performance of Molded Case Circuit Breakers.
- E. MA FU 1 - Low Voltage Cartridge Fuses.
- F. NEMA KS 1 - Enclosed Switches.
- G. NEMA PB 1 - Panelboards.

1.03 APPLICABLE PROVISIONS

- 1. Refer to Section 16010, Electrical General Provisions.

PART 2 - PRODUCTS**2.01 ENCLOSURE**

- A. Cabinet. Construct cabinets in accordance with UL 50. Use not less than 16-gauge galvanized sheet steel. Provide a minimum 10 cm gutter wiring space on each side. Reinforce cabinets and securely support bus bars and overcurrent devices to prevent vibration and breakage in handling. Provide standard conduit knockouts in ends of cabinets. Finish cabinets of surface-mounted panelboards to match doors and trim as specified below.
- B. 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 flush-mounted 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 over-hang. Apply a finish to trim and doors consisting of two coats of enamel over a rust-inhibiting prime coat.

2.02 BUS

- A. Fabricate bus of 98 percent 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. Mount neutral bars, when provided, on the end opposite end of the main lugs. Include a ground bus in panelboard rated not less than 25 percent of the main bus ampacity.

2.03 PROTECTIVE DEVICES

- A. Circuit Breakers. 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. Where indicated, provide ground fault breakers (GFCB).
 - 2- For 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 following interrupting ratings: 20,000 rms symmetrical amperes for breakers rated 220 volts, single pole, or 380 volts, three pole.
 - 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.

2.04 CIRCUIT IDENTIFICATION

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

2.05 LISTING

- A. UL 67 - Electric Panelboards.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install panelboards in the locations as shown and as recommended in NEMA PB1.1.

3.02 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 2 meters above the floor or working platform.

END OF SECTION