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**SECTION
16010**

**BASIC ELECTRICAL
REQUIREMENTS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of contract, apply to this and the other sections of Division 16.

1.2 SUMMARY

- A. This Section includes general administrative, procedural and technical requirements for electrical installations. The following requirements are included in this Section to expand the requirements specified in the General and Special Conditions of Contract:

1. General information and requirements
2. Design Conditions
3. Equipment and Materials
4. Submittals.
5. Coordination drawings.
6. Record documents.
7. Maintenance manuals.
8. Delivery, Storage and Handling
9. Rough-in
10. Electrical installations.
11. Cutting and patching.
12. Tests on Site
13. Record
14. Operation and Maintenance
15. Maintenance Contracts

B. Scope of Work

1. Electrical work, unless otherwise specified, includes the supply, installation, testing and commissioning of the complete electrical systems, equipment and materials shown on the Drawings and/or described in the Specification together with all associated ancillary work, support work and builder's work in connection.
2. Incoming power supply and connection will be provided by Local Power Authority at 11kV and 50 Hz to the location shown on the drawings.
3. Telephone public exchange lines will be brought into the premises by the Local Telephone Authority to the location shown on the drawings or to be agreed upon with Authority.

C. Related Sections: The following sections contain requirements that relate to this section:

1. Division 14 "CONVEYING SYSTEMS"
2. Division 15 for factory-installed motors.

1.3 GENERAL REQUIREMENTS A.

Installations Generally

1. carry out electrical work in accordance with the Drawings, Specification and Regulations, ensuring compliance with design and performance requirements, to provide safe and protected systems with equipment readily accessible for operation, maintenance and repair.
2. installations are to be complete, ready for operation and fully integrated and coordinated with all other work.
3. installations are to be carried out by qualified personnel.
4. provide accessories necessary to complete the installations, of the types specified or recommended for the purpose by the manufacturer of the equipment or accessories.

B. Equipment Spaces and Rooms: check that dimensions, structure, ventilating and cooling arrangements and other provisions in equipment spaces and rooms are suitable for installation, operation and maintenance of proposed equipment. Note any discrepancies on the shop and construction drawings.

- C. Systems Used Before Substantial Completion: for the benefit of the Contractor are to have all consumable elements, such as lamps etc. and defective equipment replaced by new, within 7 days prior to the date of substantial completion.
- D. Power Supply: liaise with the Local Power Authority to confirm: Characteristics of supply and system earthing.
Location of incoming supply shown on the Drawings.

Space requirements and associated builder's work for the Authority's installations.
- E. Make necessary arrangements at the earliest opportunity to ensure connection as and when required, and inform the engineer in the event of any foreseen delay.
- F. KWH-Metering: liaise with the Local Power Authority and provide necessary instrumentation, enclosures and accessories required by them to effect a complete Kwh-metering installation.
- G. Telephone Public Exchange Lines: liaise with the Local Telephone Authority to confirm location of connection of public telephone exchange lines into the premises.
- H. Factory testing for locally manufactured/assembled equipment is to comply with the relevant standards' recommendations and to be witnessed by the Engineer.
- I. Factory testing for equipment obtained from abroad is to be witnessed by the Engineer if witness test is specifically required by the relevant equipment specification sections.
- J. Spare Parts and Tools : only priced spare part lists are to be submitted with tender for each system as described here-after in the specification. Supply of the spare parts is not part of the contract. Tools and instruments necessary for equipment operation, routine inspection and maintenance as specified here- after in the specification are to be supplied as part of respective system and as part of the contract.

1.4 DESIGN CONDITIONS

- A. Nominal Characteristics of Power Supply and Distribution are as follows:

medium voltage : 11 kV, 3 phase,
3
wire

Low voltage : 380/220 V, 3 phase,
4 wires, solidly earthed
neutral

frequency : 50 Hz.

- B. Distribution systems are to be supplied or derived from the voltage system previously described, as shown on the Drawings, or as otherwise specified.
- C. Equipment is to be designed for the system voltage and frequency previously described with minimum power factor value of 0.9 unless otherwise indicated / unless otherwise specified. Special provisions are to be made for equipment sensitive to power supply , frequency and voltage variations and for equipment operated at other voltages/frequencies or by direct current sources.

- D. Climatic Conditions: all electrical equipment and material including transformers, switchgear, distribution boards/panels, cables, relays, lighting fixtures, switches, circuit breakers, UPS, central battery, etc., are to be designed and derated for continuous and trouble free service under the following climatic conditions:

altitude	:	300 m
above sea level maximum ambient		
temperature	:	50 deg. C (in the shade)
minimum ambient		
temperature	:	5 deg. C
maximum relative		
humidity	:	90%

- E. Where design and operating conditions, different from the above are required for particular equipment, they are described in the specification sections of the related equipment .

F. Regulations: unless otherwise required in the Sections that follow, of Division 16, carry out electrical work in accordance with the current issue of the local codes of practice, regulations of Cairo Electricity Distribution Company (CEDC), latest Edition of the "Regulation for Electrical Installations" (BS 7671) Issued by the "British Institute of Electrical Engineer -IEE". installation are to be carried out in conformance with the latest issue of the following regulations:

1. Recommendations for Electric systems in facilities" ANSI/IEEE std 602-1986 (white book)
2. Building building notes HBN and health technical memorandum (HTM), issued by the ministry of health, U.K.

The above regulations and codes are referred to collecting herein as the "regulations"

G. Standards: unless otherwise specified, equipment and materials are to be manufactured and installed in compliance with the relevant recommendations of the following:

IEC : The International
Electro-technical Commission ISO : The
International Standardization Organization BS :
British Standards
CCITT : The International Telephone and Telegraph
Consultative Committee
NFPA : National Fire
Protection Association

or other equal and approved standards, herein referred to as 'Standards'. Local standards, where enforced and relevant, are to have precedence over the Standards dated above.

Where any standard or code is proposed in preference to those specified, a copy of the proposed standard or code translated into English language is to be submitted with the tender. The Engineer reserves the right to insist that materials and workmanship to be the relevant specified standard where he judges that the alternative implies lower than acceptable quality.

H. Equipment locations shown on the Drawings indicate the approximate locations and general layout of equipment. Exact and final locations and layouts together with dimensions, weights, mounting methods and accessories, where relevant, are to be shown on the shop and construction drawings.

I. Wiring layouts shown on the Drawings are to be used as a guide only to defining basic positions, circuiting, loading and switching arrangements. Actual layouts and details of routing of circuits are to be shown on the shop and construction drawings.

J. Equipment and wiring layouts shown on the Drawings for work not included in the Electrical Work, such as motors and other similar electrically operated equipment are shown for information and reference only.

K. KWH Metering: provide necessary equipment, enclosure and accessories required by Local Power Authority to effect a complete KWH metering installation.

1.5 EQUIPMENT AND MATERIALS

- A. Availability: confirm availability of equipment and materials proposed for use in the work prior to submission for approval.
- B. Acceptance By Authority: confirm that proposed equipment and material characteristics where required are compatible with the requirements of the Local Power Authority or other authorities having jurisdiction and are acceptable to them. Inform the Engineer of any modifications necessary to comply with the Local Power Authority's requirements.
- C. Manufacturers' Standards: equipment is to be the latest standard product of the manufacturer.
Component parts are to be the product of a single manufacturer, unless otherwise approved , and provided that components made by other manufacturers are of a standard design and are interchangeable.
- D. Approved Manufacturers: listing of approved manufacturers in the Specification does not necessarily constitute approval of their standard products as equal to those specified. Ascertain that listed manufacturers are able to supply equipment and material in conformity with the Specification. Subject to compliance with requirements, provide products from a reputable manufacturer engaged in the field and whose products have been in satisfactory use in the similar service for not less than 5 years.
- E. Factory Assembly: equipment generally is to be supplied in complete factory assembled units ready for installation on site. Dis-assembly necessary for transportation or other purposes is to be arranged to limit site work to simple re-assembly and inter-wiring of control and power cabling.

- F. Storage Of Materials: equipment and materials are to be stored in an approved location, under cover, free from humidity, dust, debris and rodents. Equipment sensitive to heat and humidity is to be kept in climatically conditioned areas until installed and handed over.
- G. Defective Equipment: the Owner reserves the right to operate operable defective equipment during the Defects Liability Period until it can be removed from service for repair or replacement. The removal of the defective equipment/items should not affect the building operation, if necessary the Contractor shall provide a temporary replacement of the defective items until replacement.
- H. Warranty: where required by the Specification, provide a warranty, signed by the manufacturer (including his agreement to replace promptly, defective equipment or parts thereof, as instructed by the Engineer) covering materials and workmanship for the period stated in the Specification, starting at substantial completion. The Contractor is to assign the benefits of such warranty to the owner.
- I. Spare Parts: not later than the date of substantial completion, provide spare parts (as applicable) required by the Specification, together with suitable means of identifying, storing and securing same.
- J. Tools And Instruments: not later than the date of substantial completion, provide sets of tools and instruments required by the Specification, together with suitable means of identifying, storing and securing same.
- K. Label and identify all equipment, instruments, control and electrical devices etc. to indicate duty, service or function, to the satisfaction of the Engineer. Labels are to be laminated plastic or anodized aluminum discs with black surface and white core with incised lettering in English. Alternative methods of labeling may be submitted for approval. Fix labels with non-corrodible screws to equipment, or to adjacent permanent surfaces or as approved by the Engineer. Refer to Section "Electrical Identification".
- L. Equipment nameplates are to be non-corroding, robust metal, inscribed in English, and firmly fixed to equipment at factory. Nameplates are to indicate name and address of manufacturer, model, serial number, basic characteristics and ratings of equipment and are to include elementary diagrams etc., all in accordance with the Standards.
- M. Fire Sealant: materials and methods of fire sealing barriers for the various applications as required by the specification and drawings are subject to the Engineer's approval. Products are to be obtained from Hilti or approved equal.

1.6 SUBMISSIONS

- A. General: Follow the procedures specified The General & Special Conditions of Contract Section "SUBMITTALS".
- B. Increase, by the quantity listed below, the number of electrical related shop drawings, product data, and samples submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Engineer.
1. Shop Drawings - Initial Submittal: 2 additional black-line prints.
 2. Shop Drawings - Final Submittal: 2 additional black-line prints.
 3. Product Data: 2 additional copy of each item.

Additional copies may be required by individual sections of these Specifications.

- C. Generally: submit for approval, manufacturers' technical literature, shop and construction drawings and other information required by the Specification, before ordering equipment or materials and before executing any related work on site.
- D. Technical literature is to include detailed manufacturers' specifications and original catalogues or catalogue cuts, characteristics, model number, application and operating criteria of all equipment and materials, together with other information necessary to satisfy the Engineer that proposed equipment and systems are suitable and adequate.
- E. Coordination Study: submit for approval a short circuit and protection coordination study for the MV and LV distribution equipment of the project including setting of all protective relays and circuit breakers.
- F. Shop and construction drawings are to demonstrate to the Engineer that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings are to clearly state the name and location of the work, the names of the Engineer and Contractor, submission date, cross-references to the Drawings and Specification and the specific reference number, location, service and function of each item.

- G Shop and construction drawings are to be submitted as a scale of 1:50 for general layout plans, and 1:10, or 1:20 as approved by the Engineer for sections, details, elevations, congested layouts, etc. Drawings shall include but not be limited to the following:
- Details of electrical installations in conjunction with all trades concerned, showing sleeves and openings for passage through floor structure.
 - Composite construction drawings fully dimensioned, in metric, showing locations of cables, conduits, bus ducts, shafts, mechanical and electrical equipment rooms ceiling spaces and all other critical locations.
 - Plans showing equipment layouts including all details pertaining to clearances, access, sleeves, electrical connections, location and elevation of pipes, ducts, conduits, etc.
 - Plans, sections and elevations of electrical spaces to illustrate compliance with Standards for allocation of spaces for maintenance, movement, installation, etc.
- H. List of proposed manufacturers of all equipment and materials, including all items for which choice of manufacturer is at the discretion of the Contractor, is to be submitted for approval.
- I. Test Certificates and Reports: where required by the Specification, submit manufacturer's type and routine test certificates and reports for equipment and devices. Complete test results are to be submitted in clearly identified and organized booklets, indicating item of equipment, make, model, type, date of tests, type of tests, descriptions and procedures.
- J. Laboratory Tests: if manufacturer's test certificates are considered unsatisfactory, then independent laboratory tests are to be carried out on equipment in accordance with the Specification and the Standards, as required by the Engineer.
- K. Spare Parts Schedules: submit with the Tender itemized schedules of spare parts to be provided, as required by the individual sections of the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.
- L. Tools and Instruments Schedules: submit with the Tender itemized schedules of tools and instruments to be provided (if applicable) , as required by the individual sections of the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.
- M. Labeling Schedule: submit for approval, prior to installation, a schedule of all equipment and devices to be labeled and the suggested details, lettering, position and fixing methods of each label indicating its application.
- N. Samples: submit samples of all equipment and materials for approval. Major items of equipment for which samples cannot be submitted are to be demonstrated in existing installations or by manufacturer's information, test certificates and reports.

1.7 COORDINATION DRAWINGS

- A. Prepare coordination drawings in accordance with the general and special conditions of contract Section "PROJECT COORDINATION," to a scale of 1:50 or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Proposed locations of major raceway systems, equipment, and materials. Include the following:
 - a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
 - b. Exterior wall and foundation penetrations.
 - c. Fire-rated wall and floor penetrations.
 - d. Equipment connections and support details.
 - e. Sizes and location of required concrete pads and bases.
2. Scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
4. Reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communications systems components, sprinklers, and other ceiling-mounted devices.

1.8 RECORD DOCUMENT

- A. Prepare record documents in accordance with the requirements in the general and special conditions of contract Section "PROJECT CLOSEOUT". In addition to the requirements specified in Division 1, indicate installed conditions for:
1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 2. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.9 MAINTENANCE MANUALS

- A. Prepare maintenance manuals in accordance with the general and special conditions of contract Section "PROJECT CLOSEOUT". In addition to the requirements specified in the general and special conditions of contract, include the following information for equipment items:
1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 4. Servicing instructions and lubrication charts and schedules.

1.10 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
- B. Deliver products in manufacturer's packing means for type of delivery, well protected during handling and storing.

PART 2 - PRODUCTS (Not Applicable) PART 3 - EXECUTION

3.1 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

3.2 ELECTRICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
1. Coordinate electrical systems, equipment, and materials installation with other building components.
 2. Verify all dimensions by field measurements.
 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
 4. Coordinate the installation of required supporting devices and sleeves to be set in poured- in- place concrete and other structural components, as they are constructed.
 5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
- B. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

- C. Coordinate connection of electrical systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
- D. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.
- E. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
- F. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
- G. Install systems, materials, and equipment giving right-of way priority to systems required to be installed at a specified slope.

3.3 TESTS ON SITE

- A. Generally: carry out inspection and acceptance tests on site on each complete system, before final placement into service, in accordance with the Regulations and Standards, as described in the Specification and required by the Engineer.
- B. Test schedules and procedures are to be submitted for approval and are to include details of testing equipment to be provided.
- C. Witnessing: inspection and acceptance tests are to be carried out in the presence of the Engineer and, when required, by an authorized representative of the Local Power Authority.
- D. Visual Inspection: visually check proper installation, connections and nameplate data before testing.
- E. Insulation Resistance: test the feeders, lighting and power circuits, motors and other power equipment of low voltage installations with a megger of not less than 500 V d.c. for installations rated up to 500 V (r.m.s. value of a.c. supply) and 1000 V d.c. for installations rated above 500 V up to 1000 V, and as required by the particular Section of the Specification.
- F. Insulation Resistance: unless otherwise specified or approved, test the circuit insulation resistance related to communications and security systems with a megger of not less than 500 V operating voltage, with equipment disconnected.
- G. Continuity: test all feeders and circuits for continuity.
- H. Operational Tests: carry out operational tests on all equipment and complete systems to verify proper performance in compliance with the Specification. Tests are to be carried out under normal operating conditions for not less than 3 days, and as reasonably required by the Engineer.
- I. Specific Tests: carry out specific tests required by the Specification and any other tests required by the Engineer to verify compliance of the installations with the Specification.

3.4 RECORDS

- A. Generally: not later than the date of substantial completion, provide the Engineer with four copies of all approved as-installed drawings, test records, manufacturers' guarantees and warranties, operating and maintenance manuals and other records required by the Specification.
- B. Presentation of records is to be in A4 size plastic covered, loose-leaf ring binders or other approved binders with hard covers, each indexed, divided and appropriately cover titled. Drawings larger than A4 size are to be folded in the binders so that they may be unfolded without being detached.
- C. As-installed drawings are to contain the complete assembled information included on the construction drawings, prepared in the same manner, and up-dated to indicate the systems, labeling, referencing, mounting methods, routing etc. as installed. Submit complete drawings for approval. Provide the Engineer with two electronic files in addition to the four copies required.

- D. Test records are to include test certificates of type tests, routine tests, site tests, commissioning and performance tests and all other tests on equipment and installations described in the Specification and required by the Engineer. Information is to include test procedures and results, conditions under which tests were carried out including set points, temperatures and the like, dates, location and attendance by authorized representatives etc.
- E. Operating and maintenance manuals are to contain the following:
1. technical description of each system and item of equipment installed, written to ensure that the Government's staff fully understand the scope and facilities provided.
 2. diagrammatic drawings of each system indicating principle components and items of equipment.
 3. schedules (system by system) of equipment installed giving manufacturer, catalogue list numbers, model, rating, capacity and operating characteristics; each item is to have a unique code and number, cross- referenced to the diagrammatic drawings and layout drawings.
 4. name, address, telephone and fax numbers of the manufacturer of every item of equipment.
 5. name, address, telephone and fax numbers of equipment agents/representatives for emergency services and procedures.
 6. manufacturer's service manual for each major item of equipment, assembled specifically for the project, including detailed drawings, illustrations, circuit details, operating and maintenance instructions, modes of operation, control provisions, sequences and interlocks and preventative maintenance program.
 7. schedules of all fixed and variable equipment settings established during commissioning.
 8. procedures for fault finding, where applicable.
 9. manufacturers' lists of recommended spare parts for items subject to wear and deterioration, giving expected running period and indicating specifically those items, which may involve extended deliveries.
- F. Operating and Maintenance Manuals: prepare two temporary copies with provisional record drawings and preliminary performance data and make available at time of testing and commencement of commissioning to enable the **Owner** staff to familiarize themselves with the installations. Temporary copies are to be in the same format as the final manuals with temporary insertions for items which cannot be finalized until installations are commissioned and performance tested.

3.5 OPERATION AND MAINTENANCE TRAINING

- A. Before the date of substantial completion, explain and demonstrate to the owner maintenance staff the purpose, function and operation of the installations including all items and procedures listed in the operating and maintenance manuals. Include for not less than training period specified in the following individual sections.

3.6 MAINTENANCE CONTRACTS

- A. Where required by the Specification, submit supplementary proposals for annual maintenance contracts.
The proposals are to:

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1. include for maintaining the installations in efficient working order including routine and emergency service checks, adjustments, lubrication and the supply and replacement of damaged parts etc.
2. set out the terms of the offer, the work to be carried out, the guarantees of performance and the price of the work or part thereof for the first twelve months after substantial completion.

The proposals will not be considered as part of the Tender.

END OF SECTION
16010

**SECTION
16110**

**RACEWA
YS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of contract, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this Section:
1. "Basic Electrical Requirements".

1.2 SUMMARY

- A. This Section includes raceways for electrical wiring. Types of raceways in this section include the following:
1. Galvanized electrical metric tubing (EMT)
 2. Intermediate metal conduit (IMC)
 3. Rigid heavy gauge steel conduit.
 4. Flexible steel conduit.
 5. Liquid-tight flexible steel conduit.
 6. Rigid heavy gauge PVC conduit.
 7. Flexible PVC conduit.
 8. Wiring and cable trunking.
- B. Related Sections: The following Division 16 Sections contain requirements that relate to this Section:
1. "Cable Trays" for connection to raceway .
 2. "LV Wires and Cables" .
 3. "Supporting Devices" for raceway.
 4. "Electrical Cabinets, Boxes and Fittings" .

1.3 SUBMITTALS

- A. General: Submit the following in accordance with the General and Special Conditions of Contract.
- B. Product Data: manufacturer's catalogues for each type of raceway specified.
- C. Samples: 15 cm long sample of each type and size of surface raceway with required finish.
- D. Installation Instructions: manufacturer's written installation instructions for wire way, surface raceway, and non metallic raceway products.
- E. Shop Drawings: submit dimensioned drawings of raceway systems showing layout of raceways and fittings, special relationships to associated equipment, and adjoining raceways, if any. Show connections to electrical power panels and feeders. Provide the following:

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1. exact routing of conduits, trunking etc. with indication of boxes, accessories and expansion joints, size and type of conduits and boxes.
 2. typical assembly details of installation of trunking, trays etc.
 3. construction details of pull boxes
 4. typical installation details including connection of conduits to metal enclosure, connection of flexible conduits, weatherproof installations outdoors etc. and earthing connections.
- F. Maintenance Data: submit maintenance data and parts lists for each type of raceway system installed, including furnished specialities and accessories. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of the general and special conditions of contract.

1.4 QUALITY ASSURANCE

- A. Manufacturers: firms regularly engaged in manufacture of raceway systems of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
1. Codes and Standards: comply with local national code, Standards and Regulations having jurisdiction in host country or as recommended by the Authority for the project .
 2. IEC Compliance: comply with applicable IEC requirements pertaining to raceways where not in contradiction with above.
 3. BS Compliance: comply with applicable requirements of BS specifications pertaining to construction of raceway systems unless otherwise specified/approved.

1.5 SEQUENCING AND SCHEDULING

- A. Coordinate with other work, including metal and concrete deck installations, as necessary to interface installation of electrical raceways and components with other Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 STEEL CONDUIT AND TUBING

- A. General: provide steel conduit and fittings of types, and sizes as required for each service indicated.
Provide proper selection to fulfil wiring requirements in compliance with applicable portions of Codes and Standards for raceways and the applicable Regulations.
- B. Rigid Heavy Gauge Steel Conduit: heavy gauge drawn and welded steel, threaded at both ends, to BS 4568 Part 1 and BS 31 Class B (threaded), with class 4 protection for rigid steel conduit, zinc coated inside and outside by hot-dip process.
1. Fittings Generally: threaded type, galvanized or cadmium plated malleable cast iron.
Fittings used in corrosive atmospheres are to be specially treated. Fittings and components are to comply with BS 4568 Part 2 and BS 31.
 2. Locknuts: for securing conduit to metal enclosure are to be heavy hexagonal or castellated pattern, for fastening.
 3. Bushings: for terminating conduits are to be smooth rounded brass rings.
 4. Miscellaneous Fittings: including reducers, chase nipples, three piece unions, split couplings and plugs are to be standard fittings designed and manufactured for the particular application.

- C. Intermediate Metal Conduit (IMC): rigid high grade mild strip welded steel, hot dip galvanised over the entire length including factory made threads after cutting, with organic corrosion resistant polymer inside coating, to UL 1242 and ANSI C 80.6, complete with factory made bends where site bending is not possible. Factory made and threaded fittings to be used. Connectors and terminations to be with rigid coupling, concrete tight where required, and with red lead coated threads where site cut.
- D. Electrical Metallic tubing (EMT): rigid high grade mild strip steel hot dip galvanised over the entire length with organic corrosion resistant polymer inside coating to UL 797 and ANSI C 80.3, complete with factory made bends where site bending is not possible and joints terminations made with steel couplers and set screw type steel connectors with insulated throats, concrete tight where required in concrete slab installations.
- E. Flexible Steel Conduit: cold rolled and annealed, non-threaded type, formed from continuous length of helically wound and interlocked strip steel, with fused zinc coating on inside and outside, and to BS 731.
1. Fittings Generally: thread less, hinged clamp type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.
 2. Straight Connectors: one piece body, female end having hinged clamp and deep slotted machine screws for securing to conduit, male end having thread and locknut.
 3. Angle Connectors: 45 or 90 degrees terminal connectors as specified for straight connectors, except that body is to be two-piece with removable upper section.

- F. Liquid-Tight Flexible Metal Conduit: constructed of single strip, flexible, continuous, interlocked, and double-wrapped steel; galvanised inside and outside; coated with liquid-tight jacket of flexible polyvinyl chloride (PVC).
- G. Steel Conduit Accessories:
1. Sleeves Through Outside Walls: cast iron, with end and intermediate integral flanges, and internal diameter larger than diameter of through-conduit. Length is to correspond to wall thickness. Space between sleeve and conduit is to be packed with oakum to within 50 mm of both faces of wall, remainder of sleeve packed with plastic compound or lead, held in place by heavy escutcheon plates bolted at both ends to flanged ends of sleeve.
 2. Supports and Hangers: galvanised malleable cast iron straps or structural steel sections with hot dip galvanised bolts and nuts. Refer to Section "Supporting Devices" for other requirements.
 3. Expansion Joint for Embedded Steel Conduits: watertight, flexible conduit with end fittings to receive fixed conduits. Length is to allow movement within range of joint and is not to be less than 20 times diameter of conduit. Conduit is to be covered with thick rubber tubing with 5 mm minimum gap all around tube. Bonding jumper with earth clamp is to be electrically connected both sides of joint.
 4. Expansion Joint for Exposed Steel Conduits: sleeve with fittings to permit telescoping of one conduit into sleeve. Movable conduit is to be fitted with water-tight bushing. Joint is to be weatherproof, of galvanised malleable iron or steel. Bonding jumper with earth clamp is to electrically connect both sides of joint.

2.3 PVC CONDUIT

- A. General: provide PVC conduit and fittings of types and sizes indicated for each service . Where types and sizes are not indicated, provide proper selection to fulfil wiring requirements, which comply with provisions of applicable codes and standards.
- B. Rigid Heavy Gauge PVC Conduit: rigid polyvinyl chloride with high impact and high temperature resistance, flame retardant, non-hygroscopic and non-porous, conforming to IEC 423, 614-1 and 614-2, BS 4607 and BS 6099, DIN 49026 or other equal and approved standards .
1. Fittings Generally: unbreakable, non-inflammable, self extinguishing, heavy moulded plastic.
Expansion couplings are to be telescoping double tube type, with at least two inner water- tight neoprene rings.
 2. Assembly: conduits, boxes and accessories, are to be assembled by cementing, using manufacturer's recommended products and appropriate connectors or spouts. Where no spouts are available use smooth bore male PVC bushes and sockets.
- C. Flexible PVC Conduit: flame retardant, heat resistant, non-hygroscopic PVC, high resistance to impact, ribbed on circumference for flexibility.
- D. Under Ground Rigid Heavy Gauge UPVC Ducts: rigid unplasticized polyvinyl chloride to BS 3506, class B
where embedded in concrete duct banks and Class C where directly buried in ground.

2.4 WIRING AND CABLE TRUNKING

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- A. General: wiring and cable trunking is to include wire way base, clip-on covers, couplings, end plates, wall flanges, panel to trunking rubber grommets, elbows, tees, adapter plates and necessary hangers, supports and accessories. Sizes shall be as required to accommodate number of conductors permitted by the applicable standards and/or as shown on the Drawings.
- B. Steel Trunking: construct steel trunking to BS 4678 Part 1, galvanized sheet steel, minimum 1.5 mm thick, protected internally and externally with corrosion resistant finish such as zinc or cadmium with top coat of enamel.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which raceways are to be installed, and substrate which will support raceways. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Engineer.

3.2 INSTALLATION OF RACEWAYS

- A. General: install raceways as indicated and shown on construction/shop drawings, in accordance with manufacturer's written installation instructions where applicable and in compliance with applicable Code, Regulations and Standards. Install plumb and level, and maintain required clearances.
- B. Co-ordinate With Other Work: including wires/cables, boxes, and panel work, as necessary to interface installation of electrical raceways and components with other work.
- C. Use: unless otherwise specifically indicated all lighting and power circuits, communications, signal and low current systems wiring are to be drawn inside conduits or wire ways up to the various electric power consuming equipment as shown on the Drawings. Separate conduit and wire way installations are to be used for HV cables, normal lighting and power circuits, emergency lighting and power circuits, telephone, other communication, signal and low current systems wiring.
- D. Boxes: junction, pull and splice boxes of ample capacity are to be provided as indicated or required.
Boxes are to remain permanently accessible.
- E. Tools and accessories for forming and installing conduit and wire way systems are to be purpose made for the particular application and used in accordance with manufacturers' instructions.
- F. Fixing: conduits and wire way installations are to be concealed as much as possible.
- G. Sizes of conduits and wire ways, not shown on the Drawings, are to be selected in accordance with the Regulations and in relation to the number and size of conductors. Minimum size of conduit for all applications is to be 20 mm diameter, unless otherwise shown on the Drawings.

3.3 INSTALLATION OF CONDUITS

- A. General: install concealed conduits in new construction work, in walls, under floor, in slabs, or above hung ceilings. Follow indications on drawings
1. Mechanically Fasten: conduits and wire ways are to be effectively joined together and connected to electrical boxes, fittings and cabinets to provide firm mechanical assembly. Earthing jumpers are to be installed on steel conduits where required to ensure effective electrical continuity irrespective of whether a separate protective earth conductor is required or not.
 2. Avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis.

Where dissimilar metals are in contact, coat surfaces with corrosion inhibiting compound before assembling and use earth bonding jumper for electrical continuity.

3. Install miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings, and plugs that have been specifically designed and manufactured for their particular application. Install expansion fittings in straight runs of raceways every 30 meters, or wherever structural expansion joints are crossed.
4. Set conduit and boxes for connection to units only after receiving final approved drawings with dimensions and after checking location with other trades.
5. Provide 2mm diameter galvanised pull wire fastened by wood blocks or threaded iron plugs at ends in all empty conduits. Test Conduits installed, but left empty, with ball mandrel. Clear or replace any conduit, which rejects ball mandrel. Restore conduit and surrounding surfaces to original condition.
6. Sleeves: obtain approval for positioning sleeves where conduits pass through reinforced concrete.
Additional openings may be allowed in finished slabs but are to be drilled and not broken. Fix sleeves rigidly to maintain position and alignment during construction work.
7. Waterproof Construction: conduits are not to cross waterproof construction unless permitted by the Engineer. Specially designed and approved fittings are to be used.
8. Make good all holes for conduit sleeves passing through walls, floors and ceilings with fire- resisting cement or approved material to full thickness.
9. Bends: conduit runs between outlet and outlet, fitting and fitting or outlet and fitting are not to contain more than the equivalent of 2 quarter bends (180 degree total).

10. Draining: arrange conduits so that condensed moisture can drain to screwed plug at lowest point.
11. Conduit and fittings installed outdoors are to be watertight and highly resistant to corrosion. Use appropriate fittings, threaded and Hubbell boxes, gaskets with screw on covers and the like.
12. Standard elbows are to be used for conduit sizes over 40 mm. For smaller sizes, field bends may be used provided no damage occurs to conduit.
13. Tags: fit to conduits entering or leaving floors, walls or ceilings for identification of conduit and circuits. Tags are also to be placed at suitable intervals throughout the system. Refer to Section "Electrical Identification".
14. Damage to protective coating of conduits is to be repaired to original degree of protection.
15. Outdoor Mounted Steel Conduit: apply anti-corrosion coating of zinc-chromate based paint and two weather resistant finish coats of enamel, of approved colour, or other equal and approved coating.
16. Cut conduits straight, properly ream, and cut threads for heavy wall conduit deep and clean.
17. Field-bend conduit with benders designed for purpose so as not to distort nor vary internal diameter.
18. Fasten conduit terminations to boxes or enclosures by appropriate methods and terminate with bushing where conduits do not terminate in hubs.
19. Conduits are not to cross pipe shafts, or ventilating duct and openings.
20. Keep conduits a minimum distance of 150 mm from parallel runs of flues, hot water pipes or other sources of heat. Wherever possible, install horizontal raceway runs above water and steam piping.
21. Support riser conduit at each floor level with clamp hangers or other methods as described in Section "Supporting Devices".
22. Use of running threads at conduit joints and terminations is prohibited. Where required, use 3- piece union or split coupling.
23. Complete installation of electrical raceway system, including boxes, enclosures etc., before starting installation of cables/wires within raceway system. Cap empty conduits until wiring is in progress, using standard manufacturer's fittings.
24. Space occupation factor in conduits shall never exceed Code/Regulations requirements except if approved under special cases.

B. Conduit Application: Provide rigid heavy gauge galvanised steel, intermediate metal conduit (IMC), electrical metallic tubing (EMT), heavy gauge PVC conduit or other types of conduit in accordance with the following:-

1. Use rigid heavy gauge galvanised steel or IMC conduit for all exposed installations in mechanical equipment, generator rooms (except exposed lighting & small power circuit conduits in these rooms which are to be EMT type), for all exposed outdoor installations, for all feeder/sub feeder runs in non-accessible false ceiling areas, for fountain installations according to NEC, for embedded and exposed installations in hazardous explosive areas and as shown on the Drawings or specified elsewhere.
2. Use EMT for all exposed installations in elevator machine rooms and shafts, electrical equipment rooms, environmental air ducts or plenums or false ceiling areas where used as air plenums, for all exposed or above false ceiling installations of central battery system circuits, kitchen, laundry, laboratories, building care areas ,patient rooms ,radiology department, according to the NEC e.g. operating rooms, intensive care, burning units, etc. and as shown on the Drawings or specified elsewhere.
3. Use flexible conduit, metallic or non-metallic consistent with respective fixed conduit installation, in movable partitions and from outlet boxes to recessed lighting fixtures over suspended/false ceilings , and final minimum Regulation/Code length of connection to motors or

control items subject to movement or vibration, and through cellular pre cast concrete panels where required.

4. Use liquid-tight flexible steel conduit where subjected to one or more of the following conditions:
 - a. Exterior location.
 - b. Moist or humid atmosphere where condensate can be expected to accumulate.
 - c. Corrosive atmosphere.
 - d. Subjected to water spray or dripping oil, water or grease.
 5. Use rigid heavy gauge PVC conduit for embedded (in wall or slab), under-floor, concealed (in dry walls) and above false ceiling installations for lighting, power circuits and low current & communication circuits, unless otherwise indicated or specified.
 6. Use rigid heavy gauge PVC conduit for above suspended/false ceiling installations - when not used as environmental air plenum for lighting, power and low current and communication circuits unless otherwise indicated or specified.
- C. Underground Ducts: Use heavy gauge UPVC or ducts. Draw up coupling and conduit sufficiently tight to ensure water tightness. Use manufacturer's recommended cement and procedures.
1. For underground installations, unless otherwise indicated on the drawings install ducts at a minimum of 800mm below finished grade for low voltage and 1 meter for high voltage services. Use appropriate standard plastic spacers- for proper spacing of ducts.
 2. End of ducts in cable manholes, handholes walls or trenches are to be neatly cut and reamed and terminated with appropriate bell-mouth bushing in concrete wall or set behind chamfered pre cast concrete duct and blocks.

3. Ends of ducts, whether active or spare, at entry into building or manhole are to be completely sealed with approved plug and sealing material to prevent entry of rodents, gas, water, and vapour.
4. Provide 3 mm galvanised steel wire inside empty ducts, for future pulling of cables, extended 1 m beyond duct banks at both ends and security fixed to the sealing plugs of the ducts.
5. Provide 1% slope to duct banks for draining to exterior manhole, handhole or other location as instructed.

D. Conduits in Concrete Slabs:

1. Place conduits in middle third of slab thickness where practical, between bottom reinforcing steel and top reinforcing steel, leaving at least 25 mm concrete cover.
2. Place conduits either parallel, or at right angles, to main reinforcing steel and fasten to reinforcing steel by positive wire fasteners at the proper distance from the concrete face. Place conduits larger than 25 mm parallel with or at right angles to reinforcement, closest possible to slab supports.
3. Separate conduits by not less than one diameter of the larger conduit of two parallel conduits in a group, to ensure proper concrete bond.
4. Conduits crossing in slab must be reviewed for proper cover by the Engineer.
5. Embedded conduit diameter is not to exceed 1/3 of slab thickness. Special cases shall be reviewed by the Engineer.
6. Bends of embedded conduits into partitions and stub-ups shall rise a minimum of 100mm above finished floor. Stub-ups shall be galvanized rigid steel. Arrange so that the curved portion of bends is not visible above finished slab. Protect all stubs against damage.
7. Stub-up Connections: extend conduits through concrete floor for connection to free-standing equipment with an adjustable top or coupling threaded inside for plugs and set flush with finished floor. Extend conductors to equipment with rigid steel conduit. Flexible metal conduit may be used 100 mm above the floor. Where equipment connections are not made under this contract install screwdriver-operated threaded flush plugs, flush with floor.

E. Install conduits so as not to damage or run through structural members. Avoid horizontal or cross runs in building partitions or side walls.

F. Exposed Conduits:

1. Install exposed conduits and extensions from concealed conduit systems neatly, parallel with, or at right angles to nearby surfaces or structural members and follow the surface contours as much as practicable.
2. Install exposed conduit work so as not to interfere with ceiling inserts, lights or ventilation ducts or outlets.
3. Support exposed conduits by use of galvanised wall brackets, ceiling trapeze or pipe strap hangers. Support conduits on each side of bends and on linear spacing not to exceed 1.50m. Refer to Section "Supporting Devices".
4. Run conduits exposed for outlets on waterproof walls. Set anchors for supporting conduit on waterproof wall in waterproof cement.
5. Above requirements for exposed conduits also apply to conduits installed in space above hung ceilings.

G. Heavy Gauge PVC Conduits:

1. Make cemented joints in accordance with recommendations of manufacturer. Use manufacturers standard fittings, couplings, bends, terminations and cementing compound.

2. Install PVC conduits in accordance with approved applicable standards and methods .

H. Steel Conduit Fittings:

1. Fit ridged lockouts inside and outside of surface of metal enclosure to which conduit is fixed for proper fastening.
2. Bushings for terminating conduits smaller than 32mm are to have flared bottom and ribbed sides, with smooth upper edges to prevent injury to cable insulation.
3. Install insulated type bushings for terminating conduits 32mm and larger. Bushings are to have flared bottom and ribbed sides, upper edge to have phenolic insulating ring moulded into bushing.
4. Bushing of standard or insulated type to have screw type grounding terminal.
5. Miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings, and plugs to be specifically designed for their particular application.

I. Explosion Proof Fittings:

1. Explosion proof seal, drain, and breather conduit fittings shall be installed as required by code.
2. An appropriate seal shall be provided in each conduit (duct) run entering or leaving manholes, fuel pits, or other hazardous areas.
3. Combination seal and drain fittings may be used in lieu of 2 separate fittings.

3.4 INSTALLATION OF RACEWAYS AND WIREWAYS, OTHER THAN CONDUITS

- A. General: mechanically assemble metal enclosures, and raceways for conductors to form continuous electrical conductor, and connect to electrical boxes, fittings and cabinets as to provide effective electrical continuity and rigid mechanical assembly.
- B. Avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat all surfaces with corrosion inhibiting compound before assembling.
- C. Install expansion fittings in all raceways wherever structural expansion joints are crossed.
- D. Make changes in direction of raceway run with purpose made fittings, supplied by raceway manufacturer.
No field bends of raceway sections will be permitted.
- E. Properly support and anchor raceways for their entire length by structural materials. Raceways are not to span any space unsupported.
- F. Use boxes as supplied by raceway manufacturer wherever junction, pull or device boxes are required.
Standard electrical "handy" boxes, etc. shall not be permitted for use with surface raceway installations.

END OF SECTION
16110

**SECTION
16111**

**CABLE
TRAYS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section:
1. Division 7 Section "Fire Stopping" where indicated.
 2. Division 16 Section "Basic Electrical Requirements".
 3. Division 16 Section "LV Wires and Cables".

1.2 SUMMARY

- A. This section includes metallic cable trays. Types of cable trays in this section include the following:
1. Ventilated (perforated) bottom.
 2. Ladder.
- B. Cable tray support devices are specified here and in Division 16 Section "Supporting Devices".

1.3 SUBMITTALS

- A. General: submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
1. Product Data: manufacturer' catalogues and data for cable tray products and accessories.
 2. Shop Drawings: layout floor plans and elevations showing cable tray system. Designate components and accessories including clamps, brackets, hanger rods, splice plates connectors, expansion joint assemblies, straight lengths, and fittings. Show accurately scaled components and spatial relationships to adjacent equipment. Show tray types, dimensions, and finishes.
 3. Factory Test Reports: certified copies of factory test reports performed in conformance with
Standard approved on cable trays of types and size specified for this project.
 4. Field Test Reports: in compliance with "Field Testing" Article of this section.
 5. Maintenance data for inclusion in "Operating and maintenance Manual".

1.4 QUALITY ASSURANCE

- A. Manufacturers: firms regularly engaged in manufacture of cable trays and fittings of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Single-Source Responsibility: all cable tray components shall be the product of a single manufacturer. C. Coordination Drawings: include cable tray systems in coordination drawings.
- D. B.S. Compliance: comply with EN ISO 1449, Part 1: 1991 or equivalent for sheet steel and EN ISO 1461:1999 for galvanizing.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver cable tray systems and accessories packaged in factory-fabricated fiberboard type containers.
- B. Handle cable tray systems and components carefully to avoid breakage, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to manufacturer.

- C. Store cable trays and accessories in original cartons and in clean dry space; protect from weather and construction traffic.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 CABLE TRAYS, GENERAL REQUIREMENTS

- A. Cable tray systems are to be of indicated types, sizes, and standard classes and shall be complete with manufacturer's recommended covers, barrier strips, dropouts, fittings, conduit adaptors, hold-down devices, grommets, and blind ends as required and indicated.
- B. Cable tray products shall have rounded edges and smooth surfaces.
- C. Perforated type trays are to be heavy duty, heavy gauge perforated sheet steel, hot-dip galvanised after manufacture, minimum 1.5 mm thick, with sides not less than 45 mm deep, and as shown on drawings. Fitting are to be same material as tray. Covers, where shown on the drawings, are to be minimum 1.0 mm thick galvanised sheet steel, Snap-On type or forming a rigid assembly with the tray.
- D. Ladder are to be heavy duty, hot dip galvanised after manufacture, fabricated from 2 mm mild carbon steel. Ladder side channels are to be minimum 127 x 23 mm, strengthened by reinforcing inserts for torsional rigidity. Rungs are to be slotted to take cable cleats or ties and conduit clamps. Rungs are to be minimum 50 x 25 mm channels, spaced at 300 mm centers.
- E. Except as otherwise indicated, provide metal cable trays, with splice plates, bolts, nuts and washers for connecting units; capable of supporting concentrated loads of 90kg at any point, over and above full cable load.
- F. Provide cable tray covers, where indicated; construct of metals and finishes which mate and match cable trays.
- G. Provide cable tray supports and connectors, including bonding jumpers, as indicated and as recommended by cable tray manufacturer.
- H. Steel Galvanizing: is to be in accordance with EN ISO 1461 applied after fabrication, with a local coat thickness of 45 m and mean coat thickness of 55 m.
- I. Sizes: trays and ladders are to be standard metric sizes, 300, 600 and 900 mm wide, and at least 2,44 m (8 ft.) length of section. Size of tray or ladder is to be determined by number and sizes of cables in accordance with the Regulations and/or as shown on the Drawings. Tray or ladder is to have strength and rigidity to provide support for cables contained within. Deflection between supports is not to exceed
1/350 under full loading
capacity.
- J. Earthing Connector: for plastic coated trays or ladders, provide earthing connector on each coupling between adjacent sections.

2.3 MATERIALS AND FINISHES

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A. Cable Trays, Fittings, and Accessories: steel, hot-dipped galvanized after fabrication.

2.4 CABLE TRAY ACCESSORIES

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

2.5 SUPPORTS AND CONNECTORS

A. Cable tray supports and connectors, including bonding jumpers shall be as recommended by cable tray manufacturer.

B. Bolts and screws shall be cadmium plated or electrolytically galvanized.

2.6 FASTENERS FOR SUPPORTS

Fasteners to connect cable tray supports to the building structure shall be as follows: A. Expansion Anchors: carbon steel wedge or sleeve type.

B. Toggle Bolts: all steel springhead type.

C. Powder-Driven Threaded Studs: heat-treated steel, designed specifically for the intended service.

2.7 FIRE STOPPING

A. General: materials shall be approved for fire ratings consistent with penetrated barriers.

B. General: materials shall be labeled by Manufacturer for fire ratings consistent with penetrated barriers.

C. Sleeves: galvanized steel pipe sleeves. Sizes as indicated or minimum required size for cable or cable group to be installed. Provide details.

D. Sealing Fittings: Suitable for sealing cables in sleeves or core drilled holes.

2.8 WARNING SIGNS

A. Lettering: 37.5 mm (1-1/2-inch) high, black on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL".

B. Materials and Fastening: conform to Section "Electrical Identification".

PART 3 - EXECUTION

3.1 INSTALLATION OF CABLE TRAY SYSTEMS

A. Install cable trays in accordance with equipment manufacturer's written instructions. B. Remove burrs and sharp edges of cable trays.

C. Conform to manufacturer's recommendations for selection and installation of supports.

D. Strength of each support including fastenings to the structure shall be adequate to carry present and future load multiplied by a safety factor of at least four or the calculated load plus 90 kg (200 lbs), whichever is greater. Spacing of supports is not to exceed 1.5 m.

E. Installation of supports shall be in accordance with cable tray manufacturer's written instructions and recommendations.

F. Fastening Supports: unless otherwise indicated, fasten cable tray supports securely to the building structure as specified in Division 16 Section "Supporting Devices".

- G. Support at Connections to Equipment: where cable trays connect to equipment, provide flanged fittings fastened to the tray and to the equipment. Support the tray separately. Do not carry the weight of the tray on the equipment enclosure.
- H. Thermal Contraction and Expansion: install expansion connectors in cable tray runs that exceed the following length:
 - 1. Steel Tray: 52.5 m (175 feet).
 - 2. Spacings and gap settings for expansion connectors shall not exceed recommendations of approved applicable standards.
- I. Direction Changes: make changes in direction of cable tray with standard cable tray fittings.
- J. Locate cable tray above piping except as required for tray accessibility and as otherwise indicated.

- K. Firestopping: where cable trays penetrate fire and smoke barriers including walls, partitions, floors, and ceilings, install fire-stopping at penetrations after cables are installed.
- L. Sleeves For Future Cables: install capped sleeves for future cables through firestopped cable tray penetrations of fire/smoke barriers.
- M. Working Space: install cable trays with sufficient space to permit access for installing cables.
- N. Barriers: where cable trays carry conductors of different systems such as power, communication and data, or different insulation voltage levels, separate cable trays are to be used. Normal and emergency cables are to be on separate trays .In case of absolute necessity, obtain the Engineer's approval on installing cables of different systems or voltages on the same cable tray, use proper insulating barriers to separate the systems' cables and maintain the proper spacing between them according to the requirements of the codes and recommendations of the manufacturers.

3.2 EARTHING

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

3.3 WARNING SIGNS

- A. After installation of cable trays is completed, install warning signs, on or in proximity to cable trays, where easily seen by occupants of space.

3.4 FIELD TESTING

- A. Earthing: test cable trays to ensure electrical continuity of bonding and earthing connections.
- B. Anchorage: test pull-out resistance of one of each type, size, and anchorage material for toggle bolts and powder-driven threaded studs and as requested by the Engineer on site.
 - 1. Furnish equipment, including jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof-load for fastener. If fastening fails test, replace fastener and retest until satisfactory results are achieved.

3.5 CLEANING AND FINISH REPAIR

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

END OF SECTION
16111

**SECTION
16120**

**LV WIRES AND
CABLES**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section:
 - 1. "Basic Electrical Requirements."

1.2 SUMMARY

- A. This section includes wires, cables, and connectors for power, lighting, signal, control and related systems rated 600 volts and less.
- B. Extent of electrical wire and cable work is indicated by drawings and schedules.
- C. Types of electrical wire, cable, and connectors specified in this section include the following:
 - 1. Single core copper conductor/cables
 - 2. Multicore copper conductor/cables
 - 3. Fixtures wires.
 - 4. Control and signal cables.
- D. Applications of electrical wire, cable, and connectors required for project are as follows:
 - 1. For power distribution circuits.
 - 2. For lighting circuits.
 - 3. For appliance and equipment circuits.
 - 4. For motor-branch circuits.
 - 5. For signal and control circuits where not specifically required otherwise under other sections of the specification.
- E. Related Sections: the following sections contain requirements that relate to this section:
 - 1. Division 16 Section "Electrical Boxes, Cabinets and Fittings" for connectors for Terminating Cables in boxes and other electrical enclosures.
 - 2. Division 16 Section "Medium Voltage Cables" for medium voltage distribution.
 - 3. Division 16 Section "Fire Alarm System: for fire alarm cables.

1.3 SUBMITTALS

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

- B. Field Test Reports: indicating and interpreting test results relative to compliance with performance requirements of testing standards.
- C. Technical Data: submit data for approval including, but not limited to, the following:
- constructional details, standards to which cables comply, current carrying capacities, derating factors for grouping and temperature
 - manufacturer's catalogue cuts
 - dimensional and electrical characteristics
 - samples of each cable and wire and, if requested by the Engineer, other accessories.
- D. Certificate of Origin: for each lot of cable supplied, provide a certificate of origin issued by manufacturer stating origin, date of manufacture, composition, standards to which it complies and test certificates.
- E. Shop and Construction Drawings: submit drawings for approval including, but not limited to, the following:

1. exact routing layouts, sections and profiles of bus ducts , trays, feeder, sub feeder cables and branch circuits, with indication of any equipment to show and verify coordination between various trades
2. details of supports and fixings for buses, trays and cables
3. details of connections to switchboards, panel boards etc.
4. details of terminations, splices and tappings where permitted, glands and bushings at enclosures
5. number and size of conductors in conduit for all branch circuits in accordance with final conduit routing.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: comply with provisions of the statutory laws having jurisdiction and local codes of practice applicable to the job site/host country.
- B. Current carrying capacities of conductors have been determined in accordance with the Regulations for specified type of insulation and expected conditions of installation. No change will be accepted in specified type of insulation unless warranted by special conditions and approved by the Engineer. Check various loads and current carrying capacities and report any discrepancies or insufficiency of sizes indicated to the Engineer.
- C. Standards: wires and cables are to comply with IEC, BS or other equally approved standards and are to bear the mark of identification of the Standards to which they are manufactured. Wires and cables not having this identification will be rejected.
- D. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.
- E. Manufacturers: firms regularly engaged in manufacture of electrical wire and cable products of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.5 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 WIRES AND CABLES LV WIRES AND CABLES

- A. General: unless otherwise specified or shown on the Drawings, cables and other feeders are to have copper conductors. Cable conductors are to be stranded for sections 2.5 mm^2 and above, based on IEC 60228 . Signal and control cables are to have solid conductors unless otherwise specified. Flexible cords are to have finely stranded conductors. Conductors of single and multi-core cables 25 mm^2 and above are to be compacted. Multi-core cables 35 mm^2 and above are to be sectoral shape.
1. Conductor Sizes: are to be metric and as shown on the Drawings. Conductors with cross-sectional area smaller than specified will not be accepted.
 2. Building Wiring Insulation: in the absence of a national code/regulation, insulation is to be colour coded or otherwise identified as follows :
 - a. Neutral is to be black
 - b. Protective earth is to be green or green/yellow striped
 - c. Phase colours are to be selected in accordance with local regulations and IEC standards, where not in contradiction with the local regulations.

B. LV Wires

1. Single Core PVC Insulated Wires: unless otherwise specified, single conductor wires for wiring in conduit are to have annealed copper conductors, generally with concentric strands and insulated with flame retardant, moisture and heat resistant PVC to IEC 60227 suitable for wet locations and for conductor temperature of 70 deg. C. Wires are to be 450/750 V grade.

C. LV Cables

1. Multi-Core PVC Insulated Cables (0.6/1 kV): to have annealed, copper conductors, insulated with PVC to IEC 60502, flame retardant, moisture and heat resistant, suitable for wet locations and conductor temperatures of 70 deg. C, laid up, bedded with suitable filler and sheathed with PVC. Armoured cables are to have single layer of galvanized steel tape armour with PVC over sheath.
2. Multicore XLPE Insulated Feeder Cables (0.6/1 kV): single core annealed copper conductors, XLPE insulated, for conductor temperature of 90 deg. C, laid up and bedded with suitable non- hygroscopic material compatible with the insulation and PVC over sheathed, colour black. Armoured cables are to have single layer of galvanized steel tape applied helically over extruded PVC bedding (which may be an integral part of filling) and over sheathed with PVC, colour black. PVC over sheaths are to comply with IEC 60502.
3. Flexible Cable for Connection to Appliances, Window Fans, Pendants etc.: is to be 300/500 V grade to BS 6500, three or four core, with tinned finely stranded copper wires, EPR insulated, twisted and sheathed with chlorosulphonated polyethylene (CSP compound) and with strengthening cord.
4. High Temperature Fire resistant, low smoke zero halogen (LSOH) Cable : single core, stranded plain annealed copper conductors to BS 6360, mica/glass fire resistant tape cover by an extruded cross linked flame retardant LSOH insulation or equivalent to BS 7655 type EI5. Cable is to be rated 450/750 V, capable of accepting voltage surges up to 5 kV, to operate continuously at 90 deg. C. and for short durations at 200 deg. C. It is to be certified to have passed IEC 60331 and IEC 60332 part 1 fire resistance and fire retardant tests. Cables are to be used for main incoming feeders and branch circuits of central battery system panels as shown on the drawings.
5. High Temperature Cable fire resistant, low smoke zero halogen (LSOH) multicore : plain copper stranded circular conductor complying with BS 6360, class 2 Mica/Glass Fire resistant tape covered by extruded cross-linked insulation comply with BS 7655 with continuous operating temperature of 90 °C, galvanised steel wire armoured and extruded LSOH outer sheet. Cables is to be rated at 600/1000 V. It is to be certified to have passed IEC 60331, BS 6387 categories CWZ, and IE C 60332-1 flame resistance and fire retardant test. Cables are to be used to feed the fire pumps as shown on the drawings.

D. Control and Signal Cables

1. Multicore PVC Insulated Control Cables: 0.6/1 kV rating, solid 1.5 mm², 2.5 mm² or stranded 4 mm² plain circular copper conductors, with heat resistive PVC to IEC 60227, rated for 70 deg. C, of 7, 12, 19, 24, 30 or 37 cores. Cores are to be laid up together and filled with non- hygroscopic material, PVC over sheathed, to form compact and circular cable for use in switchgear, control gear and

generally for control of power and lighting systems. Armoured cable is to have extruded PVC bedding which may be an integral part of the filling, galvanized steel wire armouring, and over sheath of PVC type ST2 to IEC 60502, colour black. Core identification is to be white printed numbers 1, 2, 3 etc. over black insulation.

2. PE Insulated Control and Signal Cables: for use on instrumentation or data systems, are to be generally 300 V rating, polyethylene insulated, colour coded, tinned copper conductors (0.6 mm diameter), twisted together into pairs. Multi-pair core assembly is to be covered with binder tape, spirally wound 0.075 mm bare copper shielding tape and provided with drain wire and overall PVC sheath.
3. Control and signal cables, enclosed in conduit and raceways with power cables, are to be insulated for same voltage grade. Cables used for controlling equipment related to the life safety are to be of the fire resistance type.

E. Connectors (LV Power)

1. Connector - Type A-1: pressure indent type, for terminating or making T-taps and splices on conductors 10 mm² and smaller. Connector is to be non-ferrous copper alloy applied to conductor by mechanical crimping pressure, with vinyl insulating sleeves or phenolic insulating covers.
2. Connector - Type A-2: bolted pressure split type for terminating or making T-taps and splices on conductors 16 mm² and larger. Connector is to be cast non-ferrous copper alloy applied to conductor by clamping with minimum of two screws and provided with phenolic insulating cover.
3. Connector - Type B-1: pre-insulated, spring type, for branch circuit and fixture wiring. Connector is to be steel encased spring with shell, insulated with vinyl cap and skirt.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRES AND CABLES

- A. General: install electrical cables, wires and wiring connectors as indicated, in compliance with applicable requirements of the Regulations/codes applicable, and IEC, BS and in accordance with recognized industry practices. Building wires and cables are to be installed in conduit, trunking or ducts indoors and in conduit and ducts outdoors, unless shown otherwise on the drawings.
- B. Co-ordinate: wire/cable installation work including electrical raceway and equipment installation work, as necessary to properly interface installation of wires/cables with other work.
- C. Run d.c. wiring in separate conduits than a.c. wiring.
- D. Run: emergency lighting and power circuits in separate conduits from normal wiring.
- E. Use pulling compound or lubricant, where necessary; compound or lubricant used must not deteriorate conductor or insulation and must be approved by the Engineer.
- F. Use pulling means including, fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceway.
- G. Maintain colour coding throughout installation. Phase- conductors for which outer jacket is not colour coded are to have engraved alphanumeric mark (L1, L2, L3) or colour coded heat-shrinkable sleeves.
- H. Buried Cables: cables buried directly in the ground are to be armoured type, unless otherwise indicated in particular Sections of the Specification or on the Drawings.
- I. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.
- J. Keep conductor splices to minimum. In case of splices, these are to be inside splice boxes, pull or junction boxes.
- K. Install splices and tapes which possess equivalent-or-better mechanical strength and insulation ratings than conductors being spliced.
- L. Use splice and tap connectors which are compatible with conductor material.
- M. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in recognized standards.
- N. Pull cables simultaneously where more than one cable is being installed in the same raceway.
- O. Branch circuit work originating from light and power panelboards is to be arranged as shown on the Drawings. Loads on various phases of panelboards are to be balanced.

- P. Control cables may be fixed to racks, installed directly on cable trays or pulled in conduit and trunking indoors, and in underground ducts or in conduit outdoors.
- Q. Bunching of wires in raceways is to be in accordance with raceway filling factors permitted by the Regulations.
- R. Before pulling wires in conduits check that inside of conduit (and raceway in general) is free of burrs and is dry and clean.
- S. Support: cables and wires pulled inside very high conduit risers are to be supported at upper end of risers and at intermediate points by split rubber grommets to relieve any stresses on conductors, where required.
- T. Extra Length: at every branch circuit outlet and pull- box, every cable passing through is to be left slack to allow inspection and for connections to be made. Cables terminating in outlet boxes are to be left

with at least 250 mm extra length for terminations.

- U. Joints or taps in wires and cables, if permitted, are to be permanently accessible or made only in boxes or cabinet gutters.
- V. Connectors for terminating or making T-taps and splices are to be Type A-1 on conductors 10 mm² or smaller, Type A- 2 for conductors 16 mm² and larger, and Type B-1 for branch circuit and fixture wiring.
- W. Insulating covers are to be applied to prevent exposure of bare cable connections.
- X. Switch legs for local wall switches are to have distinctive colour, selected as complementary to cable colour coding used in the project.
- Y. Terminations: conductors of wires and cables up to 16 mm² are to be tightly twisted and where possible doubled back before being clamped with set screws. Where two or more wires are looped into same terminal these conductors are to be tightly twisted together before inserting into terminals. In no case is bare conductor to be allowed to project beyond any insulated shrouding or mounting of a line terminal. Cables sizes 16 mm² and larger are to terminate in tunnel lugs with set-screw, or by using bolted or sweated compression connectors.
- Z. Tagging: tag main and feeder cables in pull-boxes, wireways and wiring gutters of panelboards or distribution cabinets. Tags are to identify cable or circuit number and conductor size in accordance with the Schedules.
 - 1. Tagging: where two or more circuits are run to or through a control device, outlet box or ceiling junction box, each circuit is to be tagged as a guide in making connections.

3.2 FEEDER AND SUB-FEEDER CABLE INSTALLATION

- A. Cables generally are to be run through duct-banks, shafts or special recesses, clamped to steel racks or cable trays. Cables run through ventilation shafts are to be installed in steel conduits.
- B. Fixing: single cables above suspended ceilings or in concealed spaces are to be fixed directly to walls or ceilings but must be accessible. Where two or more cables are run in parallel, they are to be fixed on galvanised steel perforated trays or on other approved special cable supporting and protecting arrangement.
- C. Clamps: where cables are fixed to steel trays or supporting structures, approved galvanised cast steel clamps (or moulded plastic or die cast Aluminium clamps for single core cables) are to be used at distances not exceeding 20 diameters. Cables shall be laid parallel in one plane, with the exception of single core cables in "trefoil" formation, with a spacing between cables equal to the larger of the two adjacent cables.
- D. Joints or splices will not be accepted on main and sub- feeders. Cables are to be supplied in lengths sufficient for straight-through unjointed termination to termination pull.
- E. Cables laid direct in the ground shall be at a minimum depth of 750 mm below finished level. A 100 mm tamped bedding and 100 mm tamped covering of sifted soil or sand is to be provided with a tile cover all along the route of the cables for protection. Surface cable markers shall be provided on every change of direction and at 50 m intervals when in a straight line. A tape marker shall be embedded at 300 mm below ground level, all along the cable trench.

- F. Where cables are installed in underground ducts the ducts shall be laid with a minimum covering of 700 mm to finished level. The ends of the ducts shall be sealed immediately after any cable installation. The ends of any unused ducts shall be plugged and sealed.
1. Draw wires are to be left in all unused ducts.
 2. Just before pulling cables in, ducts shall be cleared with a mandrel 13 mm (1/2 inch) smaller than the internal diameter of the duct and followed by a circular wire brush 13 mm (1/2 inch) larger in diameter than the duct.
- G. Directly buried cables crossing under roads, pipe banks or other services, are to be drawn in heavy duty PVC duct banks. In no case are cables to be directly buried in concrete, in masonry or in floor finishings.
- H. Buried cables liable to mechanical damage are to be drawn through PVC conduit or asbestos cement pipe. If steel conduit is used, all three phase conductors, neutral and protective earth circuits are to be in the same conduit.
- I. Where multiple runs occur the cables shall be installed such that crossovers are avoided wherever practicable; if unavoidable, suitable separators for at least 1 m each side from the cross- point must be provided according to approved details.

- J. Where cables are run on ladder rack and cable tray, the size and routes of the rack and tray shall be carefully selected taking into account other services. In addition to these routes the Contractor shall include for any vertical drops of cable tray and supporting brackets where cables drop from the main runs to switchgear and equipment.
- K. In situations where individual cables pass through walls, the cables shall be sleeved and suitably sealed.
Fire barriers are to be provided as necessary by the Safety Code applicable.
- L. Cables rising from ground level up walls or stanchions shall be protected by a substantial steel frame to a height of 1.5 metres. Such framework shall be approved by the Engineer prior to the commencement of work.
- M. Exposure To Heat: route wires and cables to prevent exposure to excessive heat or to corrosive agents. If such condition is unavoidable, cables are to be type designed for particular condition.
- N. Insulating covers are to be applied to prevent exposure of bare cable connections. Insulating cover is to be purpose made and is to provide minimum insulation level equal to that of conductor insulation.
- O. Glands and cable boxes for various single-core and multicore cables are to be purpose made and suitable for rigid mounting to equipment enclosure.
- P. Cables shall be identified at regular intervals and terminations with approved cable markers.

3.3 FEEDER CABLE JOINTING AND TERMINATING

- A. Through joints will not be allowed in feeder cables where adequate manufacturer's lengths are available.
Where a joint is necessary, it has to be made inside boxes, handholes or manholes.
- B. Recommendations: through joints and terminations are to be carried out strictly in accordance with cable manufacturer's recommendations, and made with correct specified materials, boxes, tapes, compounds or mixtures, glands and bonds as applicable.
- C. Jointing: skilled operatives are to be employed for jointing of cables. Qualifications of operatives are to be submitted to the Engineer prior to work commencing on site. Joints are to be filled with epoxy resin after taping unless contrary to cable manufacturer's recommendations. Sample site constructed cable terminations and through-joints are to be submitted to the Engineer prior to commencing work on site. Samples are to be constructed in the presence of the Engineer and are to be available to the Engineer for test and inspection in accordance with manufacturer's recommendations.
- D. Cutting tools for jointing and terminating cables are to be purpose made, to prevent damage to insulation in general, and to cable sheathing..
- E. Cleaning of lacquer on conductors is to be by use of 'Scotch Brite' sponge and white spirit or equal approved.

3.4 FIELD QUALITY CONTROL

- A. Cable tests are to be carried out in accordance with the requirements of the Regulations and Standards.
- B. Test Equipment: provide megger testers of various ranges as applicable, and HV test equipment as necessary for testing MV installations. Use 500 V megger on installations with nominal voltage up to 500 V, 1000 V megger on installations with nominal voltage over 500V up to 1000V.
- C. Insulation resistance tests for LV power and lighting installations is to be measured in accordance with IEE Regulations 613-5 through 613-8 and 713-04.
- D. Insulation resistance for control and signal cables is to be minimum 10000 Megohm-km for PE insulated cables and 100 Megohm-km for PVC insulated cables, all measured core-core and core-earth, in accordance with the Regulations.
- E. Prior to energization of circuitry, check installed wires and cables with megohm meter to determine insulation resistance levels to ensure requirements are fulfilled.
- F. Prior to energization, test wires and cables for electrical continuity and for short-circuits.

- G. Subsequent to wire and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION
1612

**SECTION
16135**

**ELECTRICAL CABINETS, BOXES AND
FITTINGS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section.
 - 1. "Basic Electrical Requirements".

1.2 SUMMARY

- A. This section includes cabinets, boxes, and fittings for electrical installations and certain types of electrical fittings not covered in other sections. Types of products specified in this Section include:
 - 1. Outlet and device boxes.
 - 2. Pull and junction boxes.
 - 3. Cabinets.
 - 4. Hinged door enclosures.
- B. Related Sections: the following division sections contain requirements that related to this section.
 - 1. Division 16 - "WIRING DEVICES".
 - 2. Division 16 - "RACEWAYS".

1.3 DEFINITIONS

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

A. General: submit the following in accordance with Conditions of Contract and Division 1

Specification

Sections:

1. Product data for cabinets and enclosures and boxes of various types.
2. Shop drawings for special boxes, enclosures and cabinets that are to be shop fabricated, (nonstock items). For shop fabricated junction and pull boxes, show accurately scaled views and spatial relationships to adjacent equipment. Show box types, dimensions, and finishes. Show mounting methods, indoor, outdoor or other.

1.5 QUALITY ASSURANCE

- A. Manufacturers: firms regularly engaged in manufacture of electrical cabinets, enclosures, boxes and fittings, of types, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Standards: IEC 60439, IEC 60536, IEC 60144 and 79, NFC 63-410, BS 4662, BS 5486.1, NFC 15-100, C13-100, C12-100 or approved equal for system of wiring selected.
- C. Listing and Labeling: items provided under this section shall be listed and labeled by International standards where applicable and approved for the project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 CABINETS, BOXES AND FITTINGS, GENERAL:

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

2.3 MATERIALS AND FINISHES

- A. Sheet Steel: flat-rolled, code-gage, galvanized steel to applicable standards.
- B. Fasteners for General Use: corrosion resistant screws and hardware including cadmium and zinc plated items.
- C. Fasteners for Damp or Wet Locations: stainless steel screws and hardware.
- D. Cast Metal for Boxes, Enclosures, and Covers; copper-free aluminum except as otherwise specified.
- E. Exterior Finish: baked enamel, (gray or beige as selected by the Architect/Engineer), for items exposed in finished locations except as otherwise indicated.
- F. Painted Interior Finish: where not indicated, white baked enamel.
- G. Fittings for Boxes, Cabinets, and Enclosures: malleable iron or zinc plated steel for conduit hubs, bushings and box connectors, conformant with respective standards applicable (conduit standards applicable or approved, in host country for use with appropriate device outlets).

2.4 METAL OUTLET, DEVICE AND SMALL WIRING BOXES

- A. General: electrical metallic outlet boxes and fittings shall be of type, shape, size, and depth compatible with location and application. Refer to Section "Wiring Devices" of Division 16.
- B. Steel Boxes: boxes shall be sheet steel with stamped knockouts, threaded hubs, covers and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings and fixture studs, conforming with the approved standards of this project.

2.5 NONMETALLIC OUTLET, DEVICE AND SMALL WIRING BOXES

- A. General: conform to approved standard for "Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports" and "Nonmetallic Outlet Boxes, Flush Device Boxes and Covers". Boxes shall be moulded PVC units of type, shape, size, and depth to suit location and application. Refer to Section "Wiring Devices" of Division 16.

- B. Boxes for Concealed Work: mounting provisions and wiring entrances to suit installation conditions and wiring method used.
- C. Boxes for Exposed Work: ultra-violet stabilized, nonconductive, high impact-resistant boxes with integrally molded raceway entrance hubs and removable mounting flanges. Boxes shall be equipped with threaded metallic inserts for device and cover plate mounting screws. Each box shall have a molded cover of matching PVC material suitable for the application. Provide gasket of PVC or neoprene for outdoor or wet locations.

2.6 PULL AND JUNCTION BOXES

- A. General: comply with applicable project Standards, and Code of Practice, for boxes over 1500 cubic centimeter volume. Boxes shall have screwed or bolted-on covers of material same as box and shall be of size and shape to suit application.
- B. Hot-Dipped Galvanized Steel Boxes: sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing. Hot-dip galvanized after fabrication. Cover shall be gasketed.
- C. Cast Nonmetallic Boxes: ultra-violet stabilized nonconductive, high impact-resistant PVC boxes with gasketed cover and integral mounting flanges.

2.7 CABINETS

- A. Comply with approved applicable standards for this project.
- B. Construction: sheet steel IP30 to IEC 60144 except as otherwise indicated. Cabinet shall consist of a box and a front consisting of a one piece frame and a hinged door. Arrange door to close against a rabbet placed all around the inside edge of the frame, with a uniformly close fit between door and frame. Provide concealed fasteners, not over 600 mm (24-inches) apart, to hold fronts to cabinet boxes and provide for adjustment. Provide flush or concealed door hinges not over 600 mm (24-inches) apart and not over 150 mm (6-inches) from top and bottom of door. For flush cabinets, make the front approximately 19 mm (3/4 inch) larger than the box all around. For surface mounted cabinets make front same height and width as box.
- C. Doors: double doors for cabinets wider than 600 mm (24-inches). Cabinets wider than 1200 mm (48- inches) may have double flap or sliding doors. Removable doors will only be accepted if approved.
- D. Locks: combination spring catch and key lock, with all locks for cabinets of the same system keyed alike.
Locks may be omitted on signal, power, and lighting cabinets located within electrical closets and mechanical-electrical rooms. Locks shall be of a type to permit doors to latch closed without locking.

2.8 STEEL ENCLOSURES WITH HINGED DOORS A. Comply with IEC 60439.

- B. Construction: sheet steel, 1.5 mm (16 gage), minimum, with continuous welded seams. Protection class as indicated; arranged for surface mounting.
- C. Doors: hinged directly to cabinet and removable, with approximately 19 mm (3/4-inch) flange around all edges, shaped to cover edge of box. Provide handle

operated, key locking latch. Individual door width shall be no greater than 24-inches. Provide multiple doors where required.

- D. Mounting Panel: provide painted removable internal mounting panel for component installation.
- E. Enclosure: IP41 to IEC 60144 as otherwise indicated. Where door gasketing is required, provide neoprene gasket attached with oil-resistant adhesive, and held in place with steel retaining strips. For all enclosures of class higher than NEMA 1A, use hubbed raceway entrances.

2.9 CAST METAL ENCLOSURES WITH HINGED DOORS

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

2.10 MOULDED NONMETALLIC ENCLOSURES WITH HINGED DOOR

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

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Locations: install items where indicated and where required to suit code requirements and installation conditions.
- B. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.
- C. Support and fasten items securely in accordance with Division 16 Section "Supporting Devices".
- D. Sizes shall be adequate to meet Code or Regulation requirements, but in no case smaller than sizes indicated.
- E. Remove sharp edges where they may come in contact with wiring or personnel.

3.2 APPLICATIONS

- A. Cabinets, Indoors, Flush mounted: IP30 to IEC 60144 or except as otherwise indicated.
- B. Hinged Door Enclosures, Indoors: IP51 to IEC 60144 or enclosure except as otherwise indicated.
- C. Hinged Door Enclosures Outdoors: IP54 to IEC 60144 or with drip hood, factory tailored to individual units. D. Outlet Boxes and Fittings: install outlet and device boxes and associated covers and fittings of materials and types suitable for each location and in conformance with the following requirements:
- E. Interior Dry Locations: IP30 to IEC 60144 or NEMA type 1, sheet steel or nonmetallic as specified and/or permitted by local code.
- F. Wet Locations: IP54 to IEC 60144 or NEMA type 4 enclosures.
- G. Pull and Junction Boxes: install pull and junction boxes of materials and IEC types suitable for each location except as otherwise indicated.

3.3 INSTALLATION OF OUTLET BOXES

- A. Outlets at Windows and Doors: locate close to window trim. For outlets indicated above doors use 2100 mm mounting height above finished floor and center outlets above the door opening except as otherwise indicated.
- B. Locations in Special Finish Materials: for outlet boxes of receptacles and switches mounted in desks or furniture cabinets or in glazed tile, concrete block, marble, brick, stone or wood walls, use rectangular shaped boxes with square

corners and straight sides. Install such boxes without plaster rings. Saw cut all recesses for outlet boxes in exposed masonry walls.

- C. Gasketed Boxes: at the following locations use cast metal, threaded hub type boxes with gasketed weatherproof covers:
1. Exterior locations.
 2. Where surface mounted on unfinished walls, columns or pilasters.
(Cover gaskets may be omitted in dry locations).
 3. Where exposed to moisture laden atmosphere.
 4. Where indicated.
- D. Mounting: mount outlet boxes for switches with the long axis vertical or as indicated. Mount boxes for receptacles either vertically or horizontally but consistently either way. Three or more gang boxes shall be

mounted with the long axis horizontal. Locate box covers or device plates so they will not span different types of building finishes either vertically or horizontally. Locate boxes for switches near doors on the side opposite the hinges and close to door trim, even though electrical floor plans may show them on hinge side.

- E. Ceiling Outlets: for fixtures, where wiring is concealed, use PVC outlet boxes 100 mm (4-inches) square by 37.5 mm (1-1/2-inches) deep, minimum. For exposed installations above suspended ceilings which is not used as a plenum, use PVC outlet boxes. For exposed installations above false ceilings which is used as a plenum, use steel boxes. In areas use steel boxes.
- F. For data transmission, telephone pull boxes use metallic steel boxes.
- G. Cover Plates for Surface Boxes: use plates sized to box front without overlap.
- H. Protect outlet boxes to prevent entrance of plaster and debris. Thoroughly clean foreign material from boxes before conductors are installed.
- I. Concrete Boxes: use extra deep boxes to permit side conduit entrance without interfering with reinforcing but do not use such boxes with over 150 mm (6-inch) depth.
- J. Floor Boxes: install in concrete floor slabs so they are completely enveloped in concrete except for the top.
Where normal slab thickness will not develop box as specified above, provide increased thickness of the slab. Provide accessories in the floor boxes with earthing terminal, consisting of a washer in head machine screw, screwed into a tapped hole in the box. Adjust floor boxes flush with finished floor. Cover finish is to match floor finish. Details are subject to the Engineer's approval.

3.4 INSTALLATION OF PULL AND JUNCTION BOXES

- A. Box Selection: for boxes in main feeder conduit runs, use sizes not smaller than 200 mm square by 100 mm deep. Do not exceed 6 entering and 6 leaving raceways in a single box. Quantities of conductors (including equipment grounding conductors) in pull or junction box shall be in accordance with the applicable codes and regulations.
- B. Cable Supports: install clamps, grids, or devices to which cables may be secured. Arrange cables so they may be readily identified. Support cables at least every 75 cm (30-inches) inside boxes.
- C. Mount pull boxes in inaccessible ceilings with the covers flush with the finished ceiling.
- D. Size: provide pull and junction boxes for telephone, signal, and other systems at least 50 percent larger than would be required by Standard or Regulation, or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.

3.5 INSTALLATION OF CABINETS AND HINGED DOOR ENCLOSURES

A. Mount with fronts straight and plumb.

- B. Install with tops 1950 mm above floor.
- C. Set cabinets in finished spaces flush with walls.

3.6 EARTHING

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

3.7 CLEANING AND FINISH REPAIR

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

END OF SECTION
16135

ELECTRICAL CABINETS, BOXES AND FITTINGS
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**SECTION
16143**

**WIRING
DEVICES**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section:
1. "Basic Electrical Requirements"

1.2 SUMMARY

- A. This section includes the following:

1. Outlet boxes and plates
2. Lighting switches
3. Socket outlets
4. Dimmer Panel
5. Time controlled switches
6. Lighting contactors
7. Photoelectric cells

- B. Related Sections: the following sections contain requirements that relate to this section:

1. Division 16 Section "Circuit and Motor Disconnects" for devices other than snap (lighting) switches and plug/receptacle sets used as disconnects for motors.
2. Division 16 Section "Electrical Identification" for requirements and legends to be engraved on wall plates.
3. Division 16 Sections "Voice / Data System" and "Master Antenna TV System " for wiring devices required.

1.3 SUBMITTALS

- A. Product Data: submit manufacturer's data on each electrical wiring device specified for approval by the Engineer.
- B. Submit samples of those products indicated for sample submission in Engineer's comments on product data submittal. Include colour and finish samples of device plates and other items per Engineer's request.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: comply with provisions of the local regulations, codes and standards applicable in the project/host country. Components shall be standard approved manufacturers products, uniform and modular.

- B. Standards Compliance: provide wiring devices, which are listed and comply with applicable standards for the various applications indicated in the specification.

1.5 SEQUENCE AND SCHEDULING

- A. Schedule installation of finish plates after the surface upon which they are to be installed has received final finish.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 OUTLET BOXES AND PLATES-GENERALLY

- A. Surface or Recessed Boxes: provide compatible type with conduit or cable system and of shapes and sizes compatible with standards applicable to switches, socket outlets and lighting fixtures approved.
- B. Unused Openings: close with knock-out closers manufactured for the purpose.
- C. Blank Plates: provide blank plates on outlet boxes installed in unused space or on which no apparatus is installed or where apparatus installed does not have suitable cover for box. Blank plates for wall outlets are to be attached by a bridge with slots for horizontal and vertical adjustment.
- D. Non metallic boxes are to be used for recessed outlets in ceiling or wall.

2.3 METALLIC OUTLET BOXES

- A. Manufacturers: obtain metallic outlet boxes from same manufacturer of conduit system or equally approved compatible with wiring device specified, and to the satisfaction of the Engineer.
- B. Recessed and Concealed Boxes: galvanized pressed steel, with knock-outs for easy field installation.
Special boxes are to be punched as required on Site.
- C. Exposed Surface Mounted Boxes: galvanized cast iron with threaded hubs.
- D. Outdoor Surface or Recessed Boxes: galvanized cast iron with threaded hubs and neoprene gaskets to ensure water tightness and with stainless steel or non-ferrous, corrosion resistant screws.

2.4 MOULDED PLASTIC OUTLET BOXES

- A. Type: heavy gauge pressure moulded plastic, minimum 2 mm 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: provide 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. Provide Neoprene gaskets for weatherproof installations.

2.5 PLATES AND CORD-OUTLETS

- A. Wall Plates: single and combination, of types, sizes, and with ganging and cut outs as indicated. Provide plates which mate and match with wiring devices to which attached. Provide metal screws for securing plates to devices with screw heads

colored to match finish of plates. Conform to requirements of Section "Electrical Identification." Provide plates possessing the following additional construction features.

- B. Cord Extension Plates: are to have threaded cord grip bushings of same material and finish as plates.
- C. Stainless Steel Plates: are to be heavy gauge, pressed stainless steel, satin finish, minimum 1 mm thick, non-magnetic for static free requirements and able to withstand corrosive environments. For use in building building.
- D. White Plates: heavy gauge, for indoor use in all external buildings except where otherwise indicated, for use with switch and receptacle or similar installations.

- E. Cable/cord outlet is to be used for up to 45 A, 250 V rating for connection of power/control cable of fixed appliances. Plate is to have threaded cord grip to anchor cable securely to cover. Box is to include fixed terminal block and cable clamp for termination of cable/cord within.
- F. Plates of receptacle fed from emergency generator supply, fed from UPS supply or isolated power supply or x-ray receptacle are to be marked by engraving "Emergency", "UPS" , "ISOLATED GROUND or "X-RAY" respectively.

2.6 LIGHTING SWITCHES

- A. General: quick-make, quick-break quiet type with silver alloy contacts in arc resisting moulded base, with rocker or push-button as specified, for inductive or resistive loads up to full rated capacity, and arranged for side connection.
- B. Types: single, two-way or intermediate, single pole or double pole, as shown on the Drawings.
- C. General Lighting Switch: 10 A 250 V a.c., rocker operated, grid-switch, , all listed complies to UL20 and NEMA WD-1 with stainless steel plate, for indoor installations in Building Building.
- D. General Lighting Switch: 10A, 250 a.c. rocker operated grid switch with white plate, single module mechanism, for external buildings.
- E. Remote Lighting Control Panel for Contactor Control: multiple two ways momentary on/off push switch assembly, with an 'on' pilot light for each circuit controlled (remote contactor). Panel and box are to be sheet steel construction, with see-through steel framed acrylic door and trim, handle and lock. Enclosure protection IP 42 to IEC 60144 for indoor installation and IP 55 for outdoor installation.
- F. Weatherproof Switch: 10 A, 250 V, for installation in outdoor and wet areas of all external buildings with weatherproof plate, synthetic gasket, weatherproof outlet box, on/off indication, IP 55 enclosure.
- G. Weatherproof Switch: 10 A, 250 V, similar to type S1, but for installation in outdoor and wet areas, of the building building with weatherproof plate, synthetic gasket, weatherproof outlet box, on/off indication, IP 55 enclosure.
- H. Manual Motor Switch: 2 pole, for fractional single phase motors and appliances, to interrupt motor and induction loads, rated 30 A at 600 V a.c., toggle operated, with positive indication of on/off position of contacts.
- I. Explosion Proof Switch: 15A, 250 V, made of cast iron or aluminium alloy, class I division 1 to NEC or flame proof (Ex d) to IEC for installation in hazardous explosive areas.
- J. Three Position Switch: totally enclosed, with two positions and centre off position handle, rated 15 A, 250/440 V a.c. for dark room lighting control.

2.7 RECEPTACLE OUTLETS – GENERAL

- A. General: provide injection moulded plastic base Receptacle outlets with self-adjusting, non-expanding contacts to prevent permanent distortion, arranged for side connection and with screw terminals accepting at least three parallel branch-circuit wires.

- B. Types: provide Receptacle outlets conforming with American standard practice, UL listed UL 498 and NEMA WD-1 & WD-6 for building building.
- C. Types: provide receptacle outlets with VDE German standard for external buildings.
- D. Duplex Receptacle: provide two socket outlets mounted in parallel under one common plate with break- off feature for two circuit connection.
- E. Weatherproof Receptacle outlets provide types indicated, enclosed in surface or recessed mounted cast metal box and with spring-retained gasketed hinged flap. Enclosure is to be pre-designed box and cover for type of Receptacle outlet specified.

2.8 RECEPTACLE OUTLETS FOR BUILDING BUILDING

- A. Weatherproof Receptacle Outlet - (220 V Service): 16 A, 250 V, 2 rectangular poles plus earth, American Standard, similar to standard type but provided with rigid die cast aluminium construction with ivory epoxy finish self closing lift lid cover with heavy duty stainless steel spring complex with mounting screws . and gaskets.
- B. Standard American Receptacle -: duplex single phase, two wire, for American type plug with two rectangular pins plus earth and rated 16 A, 250 V a.c, Back and side wiring accepts up to 6 mm² wire, ivory coloured with stainless steel plate.
- C. X-Ray socket outlet: similar to standard type but black coloured
- D. Power Receptacle -: Duplex, American standard, single phase, three wire, 20 A, 250 V, Back and side wiring accepts up to 6 mm² wire, Nylon ivory, with stainless steel plate.
- E. Power Receptacle -: similar to above power type with Back and side wiring accepts up to 6 mm² wire, Nylon ivory, with stainless steel plate. suitable for outdoor use with cover comprising spring- tained gasketed hinged flap.
- F. Power Receptacle -: single outlet, 3 P+N+E, American type, 3 phase, polarized, rated 20A, 480V, with splash proof cast metal box and hunged spring – return plate, and with matching plug.
- G. Explosion Proof Receptacle Outlet: 20A, 250 V, made of cast iron or aluminium alloy, class I division 1 to NEC or flame proof (Ex d) to IEC, for installation in hazardous explosive areas.
- H. Building Grade Receptacle (HG): Duplex Receptacle, 20 Amp 250v, Building grade receptacle shall be made of a high-impact thermoplastic face and body, Ivory Nylon with one-piece slot copper alloy interfaces with the blades at three points. Terminal compartments are to be isolated from each other, automatic grounding to metallic boxes. It shall have line terminals from side and back accept # 14 to # 10 AWG, back wire holes are to allow entry of conductor insulation partially into body but not into wiring compartment. In some areas, pediatric and psychiatric locations, it shall be tamper proof hardware type.

2.9 RECEPTACLE OUTLETS FOR EXTERNAL BUILDINGS

- A. Weatherproof Receptacle Outlet - (220 V Service): 16 A, 250 V, 2 pole plus earth, German Standard, enclosed in recessed mounted cast-metal box and with cover comprising spring-retained gasketed hinged flap.
- B. Standard German Receptacle -: single phase, two wire, for plug with 3 mm round pins at 19 mm centers and with side earthing in accordance with German standard, rated 16A, 250 Va.c. with white plate, rated 16A and shatter type.
- C. Duplex Receptacle -: similar to above but duplex type
- D. Power Receptacle -: single phase, three wire, 16A, 250 V, Polarized with earth contact, splash proof moulded cast metal plate and matching plug, IP44, to IEC 60309-1 & 2.

- E. Power Receptacle-: single outlet, 3 P+N+E, 3 phase, polarized, rated 16A, 380V, with splash proof cast metal box and hunged spring – return plate, and with matching plug.
- F. Explosion Proof Socket Outlet: 16, or 20 A, 250 V, made of cast iron or aluminium alloy, class I division 1 to NEC or flame proof (Ex d) to IEC for installation in hazardous explosive areas.

2.10 PLUGS

- A. Type: compatible with type of socket outlet specified, break resistant, of impact resistant moulded insulating material (separable construction), with solid brass pins and cord grip and of shape providing easy hand-grip for removal. Special purpose type plugs are to be approved by the Engineer, UL listed complies to UL 498 and NEMA WD-1 & WD-6 for building building.
- B. Quantity: supply number of plugs equal to 50% of total number of each type of receptacle outlet supplied, for building building and 20% of total number of each type of receptacle outlet supplied for all external buildings .Supply number of receptacle adaptor (American to German type) equal to 10% of the total number of receptacle in the building building.
- C. Cord and Plug Sets: match voltage and current ratings and number of conductors to requirements of

the equipment being connected.

1. Cord: rubber-insulated, stranded copper conductors, with silicon rubber jacket. Grounding conductor has green insulation. Ampacity is equipment rating plus 30 percent minimum.

2.11 DIMMERS FOR INCANDESCENT OR FLUORESCENT LAMPS

- A. Generally: dimming control is to be suitable and rated for type and number of lamps indicated on the Drawings, and is to be electronic, programmable with thyristor control of the start of each alternating current flow.

All lighting control equipment – dimming panels, switching panels, dimming ballasts, control panel and controls are to be manufactured by single manufacturer.

- B. Dimmer panel: Dimmer panel is to be wall or floor mounted, constructed of sheet steel plates, contractor shall reinforce wall as required for wall mounted panels.

1. Panels shall be completely prewired by the manufacturer. The Contractor shall be required to provide input feed wiring, load wiring and control wiring.

2. Panels are to be cooled via free convection, unaided by fans, and capable of continuous operation to all of these section specification within an ambient temperature range of 0 deg. C. to 40 deg. C.

3. Panels fed from emergency supply: are to include electronics to bring all emergency circuits to a full – on condition upon the loss of normal power supply and the subsequent presence of emergency power. All control wires required for the above operation are to be coordinated between the dimmer and emergency panel manufacturers.

4. Under full-load conditions in 40 deg. C. environment all silicon thyristors shall operate at a minimum 20 deg. C. safety margin below the component temperature rating.

5. The maximum allowable asymmetry in the load wave form are to be +/-1 VDC.

6. Each dimmer shall incorporate an electronic "Soft-Start" default at initial Turn-on that smoothly ramps the lights up to the appropriate levels within 0.5 seconds.

7. Dimmer output voltage shall be minimum 95% of input voltage at maximum intensity setting.

- C. Schedule on drawings of each dimmer panel indicate no. of zones, load of each zone.

- D. Fluorescent Dimming: control systems are to be coordinated design, electronic, used with electronic ballasts specified for dimming, whether for standard type preheat 38 mm conventional fluorescent tubes or 26 mm tri-phosphor tubes.

- E. Variation of Luminous Intensity: to be smooth over continuous dimming range from 1% for incandescent lamps, and from 5% for fluorescent lamps, up to 100% intensity or full normal brightness.

- F. Control: preset dimming control shall provide power failure memory. Should power be interrupted and subsequently returned, the lights will come back on to the same levels set prior to the power interruption.

1. Wall station control is to have 4 button scene plus one button for raise/lower zones.

2. Wall station face plate colour is to be selected by the interior decorator.

3. Wiring from dimming panel to preset dimming control and accessory control are to be low voltage type Class 2.

2.12 LIGHTING CONTACTORS

- A. Type: double pole for single phase and neutral circuits, and triple pole for three phase circuits, mechanically held, electrically operated, rated 600 V, of current ratings shown on the Drawings, and complying with IEC 60947-4 category AC 5a for discharge lamps and category AC 5b for incandescent lamps.
- B. Contacts: copper alloy, with silver cadmium alloy double break contacts designed for switching inductive ballast loads and switching of tungsten lamp loads.
- C. Auxiliary Contacts: as required to provide specified interlocks and signals as shown on the Drawings, or required by the Specification, with one N.O. and one N.C. spare contacts.
- D. Enclosure: unless forming part of system housed in sheet steel panel, contactor is to be provided with IP 42 enclosure for indoor use or IP 65 enclosure for outdoor use.
- E. Local Control: each contactor whether part of a system or separately enclosed is to have on/off pilot lights and set of on/off push buttons mounted on cover.

- F. Central Control: provide interfacing elements to match with control system, BMS system, and remote control wiring terminals as necessary and as shown on drawings.

2.13 PHOTOELECTRIC CELLS

- A. Photoelectric Cells: omni directional cadmium sulphide, hermetically sealed, with 2:1 on/off adjustment possible by moving light level selector, set to operate at illuminance levels shown on the Drawings. Unit is to include timer giving 3 minute delay to prevent false switching. Unit must be capable of accurate operation in a temperature range of - 10 deg. C to +80 deg. C.
- B. Safety: control is to be designed such that in case of failure, unit fails in the on position. C. Contacts are to close or open as illumination level increases to set level.
- D. Outdoor Sealed Units: heavy duty cast metal, with translucent dome and approved product , to protect against high ultra violet rays, and be provided with 180 deg. swivel base and 16 mm threaded conduit mounting. Enclosure is to be weatherproof and protected against high winds and storms.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING DEVICES AND ACCESSORIES

- A. Install wiring devices and accessories as indicated, in accordance with applicable requirements, Local Electrical Code or Regulations and in accordance with recognized industry practices to fulfil project requirements.
- B. Coordinate with other Work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other Work.
- C. Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.
- D. Install galvanized steel wall plates in unfinished spaces.
- E. Locate switches at strike sides of doors, whether shown on the Drawings or not. In locating outlets allow for overhead pipes, ducts, variations in arrangement, thickness of finishings, window trim, paneling and other architectural features. Electrical Design Drawings: generally show approximate locations of outlets and equipment. Exact locations are to be determined from interior finishings and detail drawings. Any condition that would place an outlet in an unsuitable location is to be referred to the Engineer.
- F. Unless otherwise shown or instructed, mount lighting switches and socket outlets generally at 1250 mm and 450 mm from finished floor level respectively. Mount switches with long dimension vertical and operating handle, if of the toggle type, up when switch is in the on position.
- G. Connect switches in the phase wire. Do not run neutral wire through switch boxes switches having neutral shunt or bridge.
- H. Provide additional outlets to those shown on the Drawings as required by equipment manufacturers for control or other wiring.

- I. Securely Exposed Outlet Boxes: securely fasten to wall with machine screws to permanent inserts or lead anchors.
- J. Provide neat openings for recessed boxes, allowing for thickness of finishings, and use extension rings if required. Repair damaged finishings to original condition before installation of fittings or plates.
- K. Install exposed boxes and plates plumb, square and parallel to finished wall surface. Exposed plates covering recessed boxes are to rest neatly on wall surface without gaps, and fully covering the box.
- L. Arrange grouped outlets uniformly and neatly so that use of devices is convenient and clear.
- M. Follow manufacturer's instructions for installation of waterproof and explosion proof fittings and connection to conduit system to fully achieve required degree of protection.

N. Connection of Appliances:

1. Where appliance is designed to adapt directly to outlet box, extend electrical wiring to incoming terminals inside appliance
2. Where appliance is not designed to adapt to outlet box, install connecting wiring in flexible conduit or special flexible cable, mechanically protected, firmly fixed to outlet box cover plate and to terminal box on appliance, with suitable accessories.

O. Install wiring devices after wiring work is completed. P. Install wall plates after painting work is completed.

Q. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices.

3.2 PROTECTION

A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.3 FIELD QUALITY CONTROL

A. Carry out visual inspection of fittings and equipment for fixing and workmanship.

B. Testing: prior to energizing circuits, test wiring for electrical continuity, and for short-circuits.

Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six times.

C. Test ground fault interruptor operation with both local and remote fault simulations in accordance with manufacturer recommendations.

END OF SECTION
16143

**SECTION
16170**

**CIRCUIT AND MOTOR
DISCONNECTS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section:
 - 1. Basic Electrical Requirements

1.2 SUMMARY

- A. This section includes circuit and motor disconnects.
- B. Related Sections: the following sections contain requirements that relate to this section:
 - 1. Division 16 Section "Wiring Devices" for lighting switches used as motor disconnects.
 - 2. Division 16 Section "Motor Controllers" for combination type starters which incorporate disconnect switches in the same enclosure as the starter and manual motor starters which include the disconnect function as part of the starter switch assembly.
 - 3. Division 16 Section "LV Circuit Breakers" for moulded case switch, used as motor or circuit disconnect

1.3 SUBMITTALS

- A. Product data for each type of product specified.
- B. Maintenance data for circuit and motor disconnects, for inclusion in Operation and Maintenance Manual specified in the general and special conditions of contract and Division 16 Section "Basic Electrical Requirements."

1.4 QUALITY ASSURANCE

- A. Compliance with IEC: provide components complying with IEC 60408 and which are listed and labeled by an official testing laboratory or approved manufacturing standard.
- B. Compliance: comply with local Regulations / Codes applicable and/or with "IEE Regulations" where not in contradiction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 CIRCUIT AND MOTOR DISCONNECT SWITCHES (SWITCH DISCONNECTORS)

- A. General: provide circuit and motor disconnect switches in types, sizes, duties, features ratings, and enclosures as indicated. and where required by the Regulations/Code applicable. For motor and motor starter disconnects, provide units with horsepower ratings suitable to the loads.
- B. Rating: 600 V, 2, 3 or 4 pole, load break, short- circuit make, in accordance with IEC 60947-3, utilization category 22A for heating and lighting loads, category 23A for motor circuits, and with ampere rating shown on the Drawings.

- C. Design: non-fusible, air-break switch disconnecter, single throw, safety type, housed in separate metallic enclosure with arc quenching devices on each pole.
- D. Operating Mechanism: quick-make, quick-break, independent of operator, with external operating handle mechanically interlocked to prevent opening door unless switch is in open position. Switch disconnecter is to have provision for by-passing interlock. Position of handle is to be positive and clearly indicated on cover.
- E. Enclosures: general purpose sheet steel for indoor use IP 41, and weather-proof type cast-metal or sheet steel for outdoor installations IP 65, unless otherwise required or shown on the Drawings. Locking of operating handle is to be possible in open and closed positions.

2.3 SPECIAL REQUIREMENTS

- A. Electrical Interlocks: provide number and arrangement of interlock contacts in switches where indicated.

PART 3 - EXECUTION

3.1 INSTALLATION OF CIRCUIT AND MOTOR DISCONNECTS

- A. General: provide circuit and motor disconnect switches as indicated and where required by the Regulations or Code applicable. Comply with switch manufacturers' printed installation instructions.

3.02 FIELD QUALITY CONTROL

- A. Testing: subsequent to completion of installation of electrical disconnect switches:
 - 1. Before energization, carry out insulation resistance testing on switch when in the off position, line side; test load side insulation as applicable to the load connected.
 - 2. Energize circuits and demonstrate capability and compliance with requirements. Except as otherwise indicated, do not test switches by operating them under load. However, demonstrate switch operation through six opening/closing cycles with circuit unloaded. Open each switch enclosure for inspection of interior, mechanical and electrical connections, fuse installation, and for verification of type and rating of fuses installed. Correct deficiencies then retest to demonstrate compliance. Remove and replace defective units with new units and retest.

END OF SECTION
16170

**SECTION
16190**

**SUPPORTING
DEVICES**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section:
 - 1. "Basic Electrical Requirements".

1.2 SUMMARY

- A. This section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.
- B. Related Sections: the following Sections contain requirements that relate to this Section:
 - 1. Division 3 Section "Concrete Accessories" for inserts, anchors, and sleeves to be installed in concrete for use with supporting devices.
 - 2. Division 5 Section "Metal Fabrications" for requirements for miscellaneous metal items involved in supports and fastenings.
 - 3. Division 7 Section "Joint Sealers" for requirements for firestopping at sleeves through walls and floors that are fire barriers.
 - 4. Refer to other Division 16 sections for additional specific support requirements, through wall sleeves for conduit and cable, straps, saddles and bearing components that are applicable.

1.3 SUBMITTALS

- A. General: submit the following in accordance with the general and special Conditions of Contract.
- B. Product data for each type of product specified.
 - 1. Hanger and support schedule showing manufacturer's figure number, size, spacing, features, and application for each required type of hanger, support, sleeve, seal, and fastener to be used.
- C. Engineered design consisting of details and engineering analysis for custom built supports.
- D. Shop drawings indicating details of fabricated product and materials.

1.4 QUALITY ASSURANCE

- A. Manufacturers: firms regularly engaged in manufacture of supports of various kinds and capacities required, whose products have been in satisfactory use in similar service for not less than 3 years.

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- B. Support Component Standards: components and installation shall comply with applicable local codes and standard details approved for the project.
- C. Support components shall be listed and labeled by BS, DIN or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

PART 2 - PRODUCTS

2.1 COATINGS

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

2.2 MANUFACTURED SUPPORTING DEVICES

- A. Raceway Supports: clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.
- B. Strirrup Clamps: hot-dip galvanized steel, with metal or plastic spacer, clamping pads and hexagonal screw to suit the application, fixable to channel rails, flats and angle iron. Hex screw to be with two-start thread and head qualifying for wrench or screw driver application.
1. U-channel of hot-dip galvanized steel, is to be appropriately sized for stirrups and loading capacity.
- C. Fasteners: types, materials, and construction features as follows:
1. Expansion Anchors: carbon steel wedge or sleeve type.
 2. Toggle Bolts: all steel, springhead type.
 3. Powder-Driven Threaded Studs: heat-treated steel, designed specifically for the intended service.
 4. Fibre -plastic or lead inserts with applicable screw sizes of galvanized steel for fixing single run conduit clamps, clips and saddles.
- D. Conduit Sealing Bushings: factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.
- E. Cable Supports in Vertical Conduit: factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.
- F. U-Channel Rail Systems: minimum 2 mm (16-gage US) galvanized steel channels, with 14 mm (9/16- inch)- diameter holes, at a minimum of 8 inches (200 mm) on center, in top surface. Provide fittings and accessories that mate and match with U-channel rail and are of the same manufacture. Provide modular clamps and slide-in spacers of impact and fire resistant polystyrene or metal spacers to suit the requirements.

2.3 FABRICATED SUPPORTING DEVICES

- A. General: shop or field-fabricated supports or manufactured supports assembled from U- channel components.
- B. Steel Brackets: fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

- C. Pipe Sleeves: provide pipe sleeves of one of the following:
1. Steel Pipe: fabricate from Schedule heavy gauge galvanized steel pipe.
 2. Plastic Pipe: fabricate from Schedule extra heavy gauge PVC plastic pipe.
 3. Refer to Section "Raceways" for other type of sleeves.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install supporting devices to fasten electrical components securely and permanently in accordance with regulations.
- B. Coordinate with the building structural system and with other electrical installation.
- C. Raceway Supports: comply with the applicable approved local or other international code, and the following requirements:
1. Conform to manufacturer's recommendations for selection and installation of supports.
 2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 90 kg (200 lbs), provide additional strength until there is a minimum of 90 kg (200 lbs) safety allowance in the strength of each support.
 3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
 4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
 5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 38 mm (1-1/2-inch) and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 6 mm (1/4-inch)-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
 6. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with Local Codes and Regulations .
 7. Support exposed and concealed raceway within 300 mm (1 foot) of an unsupported box and access fittings. In horizontal runs, support at the box . Access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
 8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports and not by raceway terminals.
- D. Vertical Conductor Supports: install simultaneously with installation of conductors.
- E. Miscellaneous Supports: support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.
- F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches (600mm) from the box.

- G. Sleeves: install in concrete slabs and walls and all other fire- rated floors and walls for raceways and cable installations. For sleeves through fire rated-wall or floor construction, apply firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with "Fire Resistant Joint Sealers" requirement of Division 7 Section "Joint Sealers".
- H. Conduit Seals: install seals for conduit penetrations of slabs on grade and exterior walls and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.
- I. Fastening: unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:
1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs, to steel structures. In partitions of light steel construction, use sheet metal screws.
 2. Holes cut to depth of more than 1-1/2 inches (40 mm) in reinforced concrete beams or to depth of more than 3/4 inch (20 mm) in concrete slabs shall not cut the main reinforcing bars. Fill

holes that are not used. Coordinate with Engineer before cutting holes.

3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load.
Use vibration-and shock-resistant fasteners for attachments to concrete slabs.

3.2 TESTS

A. Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:

1. Expansion anchors.
2. Toggle bolts.
3. Powder-driven threaded studs.

B. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof test load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

3.3 TABLE I- SPACING FOR RACEWAY SUPPORTS

A. Supports: use approved clamps, hangers or clips fastened by machine screws to expansion sleeves in inserts or to lead anchors.

B. Spacing of clamps or clips for supporting steel conduits is not to be greater than: Conduit Size
Maximum Spacing of Supports

<u>mm (inches)</u>	<u>metres (feet)</u>
20 (3/4)	1.5 (5)
25 (1)	1.5 (5)
32-38 (1-1/4 - 1-1/2)	2 (6.5)
50-63 (2 - 2-1/2)	2 (6.5)
75 (3) and larger	2.5 (8)

C. Spacing of clamps or clips for supporting PVC conduits is not to be greater than: Conduit Size

Maximum Spacing of Supports
mm (inches)

metres (feet)

	<u>Conductors Rated</u> <u>60 deg.C and below</u>	<u>Conductors Rated</u> <u>more than 60 deg.C</u>
20 (3/4)	1.25 (4)	0.60 (2)
25-50 (1 - 2)	1.50 (5)	0.75 (2-)
63-75 (2-1/2 - 3)	1.80 (6)	0.90 (3)
90-125 (3-1/2 - 5)	2.00 (7)	1.00 (3-)
150 (6)	2.50 (8)	1.25 (4)

END OF SECTION
16190

**SECTION
16195**

**ELECTRICAL
IDENTIFICATION**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section:
 - 1. "Basic Electrical Requirements".

1.2 SUMMARY

- A. This section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:
 - 1. Buried electrical line warnings.
 - 2. Identification labelling for raceways, cables, and conductors.
 - 3. Operational instruction signs.
 - 4. Warning and caution signs.
 - 5. Equipment labels and signs.
- B. Related Sections: the following Sections contain requirements that relate to this Section:
 - 1. Division 9 Section "Painting" for related identification requirements.
 - 2. Division 16 Section " LV Wires and Cables" and "MV cables" for requirements for color coding of conductors for phase identification.
- C. Refer to other Division 16 sections for additional specific electrical identification associated with specific items.

1.3 SUBMITTALS

- A. General: submit the following in accordance with the general and special Conditions of Contract.
 - B. Product data for each type of product specified.
 - C. Schedule of identification nomenclature to be used for identification signs and labels.
 - D. Samples of each color, lettering style, and other graphic representation required for identification materials; samples of labels and signs.

1.4 QUALITY ASSURANCE

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- A. Firms regularly engaged in manufacture of electrical identification products of types required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. EN Compliance: comply with EN 50005 ,50042, 60439,60445 as applicable to electrical equipment. C. IEE Compliance: comply with IEE Wiring Regulations (BS 7671), BS 1710 for conduit colour.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Firm regular engaged in manufacture of electrical identification products of types required, whose products have been in satisfactory use in similar service for not less than 3 years.

2.2 ELECTRICAL IDENTIFICATION PRODUCTS

- A. Adhesive Marking Labels for Raceway and Exposed Armoured Cable: Pre- printed, flexible, self-adhesive labels with legend indicating voltage and service (Emergency, Lighting, Power, Power a.c., Air Conditioning, Communications, Control, Fire, etc.)
- B. Adhesive Label Size: as follows:
1. Raceways 25 mm (1-Inch) and Smaller 30 mm: (1-1/8 inches) high by 200 mm (4 inches) long.
 2. Raceways larger than 25 mm (1-2 inch): 30 mm (1-1/8 inches) high by 300 mm (8 inches) long.
- C. Color: black legend on orange background.
- D. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: self-adhesive vinyl tape not less than 3 mils thick by 25 mm (1 inch) to 50 mm (2 inches) in width.
- E. Pretensioned Flexible Wraparound Colored Plastic Sleeves for Raceway and Cable Identification: flexible acrylic bands sized to suit the raceway diameter and arranged to stay in place by pre-tensioned gripping action when coiled around the raceway or cable.
- F. Underground Line Marking Tape: permanent, bright-colored, continuous-printed, plastic tape compounded for direct-burial service not less than 150 mm (6 inches) wide by 4 mils (0.1 mm) thick. Printed legend indicative of general type of underground line below.
- G. Wire/Cable Designation Tape Markers: vinyl or vinyl-cloth, self-adhesive, wraparound cable/conductor markers with preprinted numbers and letter.
- H. Aluminum, Wraparound, Cable Marker Bands: bands cut from 0.4 mm (0.014- inch) thick, aluminum sheet, fitted with slots or ears for securing permanently around wire or cable jacket or around groups of conductors. Provide for legend application with stamped letters or numbers.
- I. Plasticized Card Stock Tags: vinyl cloth with preprinted and field-printed legends to suit the application.
Orange background, except as otherwise indicated, with Eyelet for fastener.
- J. Aluminum-Faced Card Stock Tags: weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.050 mm (0.002 inches) thick, and laminated with moisture- resistant acrylic adhesive. Pre-print legend to suit the application, and punch for tie fastener.

- K. Brass or Aluminum Tags: metal tags with stamped legend, punched for fastener.
Dimensions: 50 mm
(2 inches) by 50 mm (2 inches) by 1 mm (19 gage).
- L. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: engraving stock melamine plastic laminate, 1.5 mm (1/16-inch) minimum thick for signs up to 2500 sq.cm (20 square inches) or 200 mm (8 inches) in length; 3.0 mm (1/8-inch) thick for larger sizes. Engraved legend in white letters on black face and punched for mechanical fasteners.
- M. Baked-Enamel Warning and Caution Signs for Interior Use: preprinted aluminum signs, punched for fasteners, with colors, legend and size appropriate to the location.
- N. Exterior Metal-Backed Butyrate Warning and Caution Signs: weather-resistant, nonfading, preprinted cellulose acetate butyrate signs with 1.00 mm (20-gage), galvanized steel backing, with colors, legend and size appropriate to the location. Provide 6 mm (1/4-inch) grommets in corners for mounting.
- O. Fasteners for Plastic-Laminated and Metal Signs: self-tapping stainless steel screws or number
10/32 stainless steel machine screws with nuts and flat and lock washers.
- P. Cable Ties: fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 4.5 mm (0.18-inch)
minimum width, 22 kg (50-lb) minimum tensile strength, and suitable for a temperature range from minus

10 deg. C. (50 deg F) to 177 deg. C. (350 deg F.) Provide ties in specified colors when used for color coding.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lettering and Graphics: coordinate names, abbreviations, colours, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colours as approved in submittals and as required by code.
- B. Install identification devices in accordance with manufacturer's written instructions and requirements of Standard applicable BS (or other approved).
- C. Sequence of Work: where identification is to be applied to surfaces that require finish, install identification after completion of finish work.
- D. Identify high-voltage feeder raceway (over 600 V) by words "DANGER-HIGH VOLTAGE" in black letters 50 mm (2 inches) high, stenciled at 3m (10-foot) intervals over continuous painted orange background.
1. The following areas shall be identified:
 - a. On entire floor area directly above conduits running beneath and within 12 inches (300 mm) of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
 - b. On all accessible surfaces of concrete envelope around conduits in vertical shafts, exposed at ceilings or concealed above suspended ceilings.
 2. Apply identification to areas as follows:
 - a. Clean surface of dust, loose material, and oily films before painting.
 - b. Prime surfaces: for galvanised metal, use single- component acrylic vehicle coating formulated for galvanised surfaces. For concrete masonry units, use heavy- duty acrylic resin block filler. For concrete surfaces, use clear alkali-resistant alkyd binder-type sealer.
 - c. Apply one intermediate and one finish coat of orange silicone alkyd enamel.
 - d. Apply primer and finish materials in accordance with manufacturer's instructions.
- E. Identify Junction, Pull, and Connection Boxes: code-required caution sign for boxes shall be pressure- sensitive, self- adhesive label indicating system voltage in black, preprinted on orange background. Install on outside of box cover. Also label box covers with identity of contained circuits. Use pressure- sensitive plastic labels at exposed locations and similar labels or plasticized card stock tags at concealed boxes.
- F. Underground Electrical Line Identification: during trench backfilling, for exterior underground power, signal, and communications lines, install continuous underground plastic line marker, located directly above line at 150 mm (6) to 200 mm (8 inches) below finished grade. Where multiple lines installed

in a common trench or concrete envelope, do not exceed an overall width of 400 mm (16 inches); install a single line marker.

- G. Limit use of line markers to direct-burial cables.
- H. Conductor Color Coding: provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as given in Division 16, Sections " LV Wires and Cables" and "MV Cables".
- I. Use conductors with insulation and sheathing color factory-applied the entire length of the conductors except in renovated existing installation
 - 1. The following field-applied colour-coding methods may be used in lieu of factory-coded wire for sizes larger than 6 sq. mm.
 - a. Apply coloured, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 25 mm (1- inch) wide tape in colours as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.

two lines are required), white lettering in black field. Text shall match terminology and numbering of the Contract Documents and shop drawings. Apply labels for each unit of the following categories of electrical equipment.

- a. Panel boards , electrical cabinets, and enclosures.
- b. Access doors and panels for concealed electrical items.
- c. Electrical switchgear and switchboards (LV and MV).
- d. Motor control centers.
- e. Motor starters.
- f. Pushbutton stations.
- g. Power transfer equipment.
- h. Contactors.
- I. Remote-controlled switches.
- j. Dimmers.
- k. Control devices.
- l. Transformers.
- m. uninterruptible power supply (UPS).
- n. Battery racks.
- o. Central Battery system.
- p. Voice & data equipment.
- q. MATV equipment.
- r. CCTV equipment
- s. Fire alarm system equipment and control panels.
- t. Public Address and local sound systems equipment.
- u. Intercom system equipment.
- v. Nurse call system equipment.
- w. Diesel Generator sets
- x. Voltage regulator
- y. Bus way
- z. Master Clock

2. Apply circuit/control/item designation labels of engraved plastic laminate for disconnect switches, breakers, pushbuttons, pilot lights, motor control centers and similar items for power distribution and control components above, except panel boards and alarm/signal components, where

labelling is specified elsewhere. For panel boards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

3. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

END OF SECTION
16195

**SECTION
16291**

**BUILDER'S WORK IN
CONNECTION WITH ELECTRICAL
WORK**

PART 1 - GENERAL

1.1 BUILDER'S WORK GENERALLY

- A. Materials and workmanship, unless otherwise specified, are to be in accordance with the relevant requirements of the Specification for Structural and Architectural work.

1.2 DESCRIPTION OF WORK

- A. Cable and duct trenches, equipment foundations, bases and supports, ducts and duct banks, manholes, handholes and earth pits, chases, holes and the like, sleeves, bolts, brackets and fixings including grouting.

1.3 COORDINATION

- A. Confirm locations and dimensions of all builder's work required for electrical work. Submit shop and construction drawings or other data to the Engineer for checking before proceeding with the work.

1.4 ROUTES FOR SERVICES BELOW GROUND

- A. Agree precise locations with the Engineer, set out clearly and accurately and locate with temporary marker posts.

PART 2 - PRODUCTS AND MATERIALS

2.1 COMPONENTS

- A. POLYVINYL CHLORIDE (PVC) DUCTS for outdoor power and lighting cable installations are to be non-sparking type, suitable for direct burial in ground, minimum tensile strength 500 kg/cm², impact strength 5 kg/cm², supplied in standard 6 m lengths, with one end of each length tapered. Ducts are to be nominal size shown on the Drawings, with minimum wall thickness 3.2 mm for 100 mm ducts and 4.7 mm for 150 mm ducts.
- B. Duct Supports: pre-formed, non-metallic of approved type. Supports containing metal are to have the metal non-continuous and not forming a magnetic loop in any manner.
- C. Covers for Trenches in electrical rooms and the like, unless otherwise specified or shown on the Drawings, are to be flanged chequered steel plates with angle or channel-section frames, suitably reinforced to support anticipated loads, and finished with zinc chromate primer and two coats grey enamel.

- D. Covers for Manholes and Handholes: to BS 497, chequered cast iron or cast steel, recessed type, and of suitable duty for the particular application.
- E. Brackets, Supports, Rails and Tracks for supporting electrical installations are to be galvanized steel, fixed with expansion bolts of approved size and material. Plastic inserts and lead anchors are not acceptable unless approved for specific light duty installations.

2.2 COMPOSITE CONSTRUCTION

- A. Equipment Foundations and Bases: reinforced concrete, as approved by the Engineer after submission of design calculations. Dimensions, levels and surface finishes are to be suitable for equipment installed, as shown on the Drawings or in accordance with approved shop and construction drawings.
- B. Concrete Envelope for Duct Banks for power distribution systems and outdoor lighting cable installations crossing water, gas and sewage mains, under roadways and where required or shown on the Drawings, is to be reinforced concrete Class B using sulphate-resisting Portland cement. Reinforcement is to consist of 12 mm diameter longitudinal bars at approximately 300 mm centres along bottom and sides of duct bank with 10 mm diameter U-shaped transversal bars at 400 mm centres. Length of concrete envelope is to extend at least 300 mm beyond each side of crossing etc.

- C. Cable Manholes and Handholes: reinforced concrete Class B using sulphate-resisting Portland cement, with approved waterproof membrane on external surfaces, and with cable supports where necessary, pull- eyes, and drain pit and drain pipe as required. Dimensions and reinforcement are to be as shown on the Drawings or in accordance with approved standard details shown on shop and construction drawings.

PART 3 - EXECUTION

3.1 CABLE TRENCHES

- A. Cable Trenches: width is to be as small as practicable with sides vertical. Remove mud, rock projections, boulders and hard spots from trench bottom and trim level. Inform the Engineer in advance to give him reasonable opportunity to inspect trench for each section of the work.

3.2 DIRECTLY BURIED PVC CABLE DUCTS

- A. Lay and join ducts to required line and level on sand bed, cover with sand and backfill trench to ground level with excavated soil, free from stones and other debris, well compacted in layers not exceeding 300 mm thick Lay approved concrete tiles to fully cover cable duct, extending minimum 50 mm beyond sides of duct and placed 300 mm below ground level. Provide warning tape or galvanized steel mesh along duct runs at a depth 200 mm below ground level.

- B. Underground cable duct assemblies:

form duct assembly to required line and level, using duct supports spaced to prevent sagging of ducts and breaking of couplings and watertight seals, and secured with cords (not tie wires) where necessary.

Provide 1% slope to duct banks for draining to exterior manhole, handhole or other location as instructed. Join ducts using waterproof cement, to manufacturer's recommendations, to give waterproof and sandproof joint with at least 80 mm overlap. Provide 3 mm galvanized steel wire inside empty ducts, for future pulling of cables, extending 1 m beyond duct banks at both ends and securely fixed to wooden bungs sealing the duct.

- C. Ends of ducts:

ducts ending in cable manholes or handholes are to be neatly cut and reamed and set behind chamfered precast concrete duct end blocks or terminated with appropriate bell-mouth bushing set in concrete wall. Ducts not ending in cable manholes or handholes are to be properly capped.

- D. Sealing ends of ducts:

conduits and ducts, active or spare, at entry into building or manhole, are to be completely sealed with approved plastic moulds or wooden bungs to prevent entry of rodents, gas and vapour.

3.3 SLEEVES OR DUCTS IN EQUIPMENT FOUNDATIONS

- A. Are to be provided, whether shown on the Drawings or not, and in accordance with approved shop and construction drawings or as instructed by the Engineer. Obtain approval of sleeve or duct installation prior to concreting.

3.4 SUPPORT FRAMES FOR SWITCHGEAR

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- A. Located over cable trenches, where shown on the Drawings or required by equipment design, are to be installed prior to concreting.
- B. Drilling for anchor bolts is to be carried out using appropriate electric drills and in approved positions.
- C. Holes and chases in SITU concrete are to be cast in. Do not cut hardened concrete or drill holes larger than 10 mm diameter without prior approval.
- D. Holes and chases in precast concrete: do not cut or drill precast concrete without prior approval. E. Holes in structural steelwork: do not cut or drill structural steelwork without prior approval.
- F. Holes and chases in masonry must not exceed:
- | | | |
|----------------------------|---|----------------------------------|
| size of holes | : | 300 |
| mm square | | |
| depth of vertical chases | : | 1/3 wall thickness or, in cavity |
| walls, 1/3 leaf thickness | | |
| depth of horizontal chases | : | 1/6 wall or |
| leaf thickness. | | |

3.5 Cutting masonry

- A. Ensure mortar is fully set before commencing.

- B. Cut carefully and neatly, avoiding spalling, cracking or other damage to surrounding structure.
- C. Keep holes to smallest practicable size and do not exceed specified -dimensions.
- D. Cut chases in straight lines and horizontally and vertically only; do not set back to back; offset by a distance not less than wall thickness.

3.6 Preformed holes in masonry

- A. submit proposals for bridging over holes for ducts etc. which exceed 460 mm width.

3.7 INSPECTION AND CLEANING

- A. Inspection of duct systems: directly buried ducts and underground duct assemblies are to be inspected in the presence of the Engineer, before backfilling or concreting. Steel mandrel or other approved device, diameter equal to 90% of inside diameter of duct and 500 mm long, is to be pulled through entire run of duct and is to pass through without getting stuck. Ducts which do not allow mandrel to be pulled through are to be repaired or replaced to the satisfaction of the Engineer.
- B. Clean ducts with stiff bristle brush pulled through each duct prior to pulling in cables.

END OF SECTION
1629

**SECTION
16452**

**EARTHIN
G**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to work of this section.
- B. Requirements of the following Division 16 Sections apply to this Section:
1. "Basic Electrical Requirements."

1.2 SUMMARY

- A. Description of Work: this section includes complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TN-S system arrangement, including:
1. exposed conductive parts of electrical equipment
 2. extraneous conductive parts
 3. earthing of radiology department rooms
 4. earthing of patient care area
 5. earthing of telephone and electronic equipment
- B. Related Sections: the following sections contain special requirements that relate to this section:
1. Division 14 for "Elevators" and "Materials Handling
 2. Division 16 for "Wires and Cables" for earthing system.
 3. Division 16 for "Lightning Protection System".

1.3 DEFINITIONS OF TERMS

- A. "Grounding" or "Ground" used in other sections or divisions of the specification are interchangeably used as "Earthing" or "Earth".
- B. Earth: conductive mass of the Earth whose electric potential at any point is conventionally taken as zero
- C. Earth Electrode: conductor or group of conductors in initial contact with, and providing electrical connection to, Earth
- D. Exposed Conductive Part: any part which can be readily touched and which is not a live part but which may become live under fault conditions
- E. Extraneous Conductive Part: any conductive part not forming part of the electrical installation such as structural metalwork of a building, metallic gas pipes, water pipes, heating tubes etc. and non- electrical apparatus electrically

connected to them i.e. radiators, cooking ranges, metal sinks, etc. and non-insulating floors and walls

- F. Protective Conductor: conductor used for some measure of protection against electric shock and intended for connecting together any of the following parts:

exposed conductive
parts extraneous
conductive parts earth
electrode(s)
main earthing terminal or bar(s)
earthed point of the source(s)

- G. Electrically Independent Earth Electrodes: earth electrodes located at such distance from one another that maximum current likely to flow through one of them does not significantly affect the potential of the other(s)

- H. Main Earthing Terminal or Bar: the terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing

- I. Equipotential Bonding: electrical connection to put exposed and extraneous conductive parts at a substantially equal potential
- J. Earthing Conductor: protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.

1.4 SUBMITTALS

- A. General: submit the following in accordance with the general and special Conditions of Contract. B. Product Data: for earth rods, connectors and connection materials, and earthing fittings.
- C. Equipment Data: prior to ordering materials, submit data for approval including, but not limited to, manufacturer's catalogues for earth rods, connecting clamps, earthing conductors, protective conductors, bonding conductors, connectors and other accessories, exothermic welding kits and tools, etc., and samples of conductors as requested.
- D. Shop and Construction Drawings: submit drawings for approval including, but not limited to, the following:
 - 1. exact location of earth pits, rods and details of installation and connections
 - 2. exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering
 - 3. cross sectional area of all earthing, protective and bonding conductors
 - 4. layout and details of earthing provisions at substations, generator rooms, switchgear, distribution panel boards , etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches, etc., giving sizes and dimensions of component parts.
- E. Field Testing Organization Certificate: signed by the Contractor, certifying that the organization performing field tests complies with the requirements specified in Quality Assurance below.
- F. Report of field tests and observations certified by the testing organization.
- G. Report of field tests and observations certified by the Engineer. (All tests shall be carried out in the presence of and be certified by the Engineer).

1.5 QUALITY ASSURANCE

- A. Regulations and Standards: carry out work in accordance with the following:
 - 1. BS EN publications 60439
 - 2. BS7671: Requirements for Electrical Installations. (IEE Wiring Regulations).
 - 3. NFPA 70
- B. Field-Testing Organization Qualifications: to qualify for acceptance, the independent testing organization must demonstrate, based on evaluation of organization-submitted criteria, that it has the experience and capability to conduct satisfactorily the testing indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 GENERAL REQUIREMENTS

- A. Component parts of earthing system are to include the following:
1. earth electrode (rods, tapes etc.)
 2. main earthing terminals or bars
 3. earthing conductors
 4. protective conductors
 5. equipotential bonding conductors
 6. electrically independent earth electrodes for special systems
 7. accessories and termination fittings, bonding, welding kits and other materials.

- B. Earth Electrode: consisting of earth rods interconnected with earth loops, and bonded to the building steel reinforcing bars. The earth loop conductors are to be buried around the perimeter of the building at 1 m (min.) below the finish grade level and 0.6 m away from the building.
- C. Overall resistance to earth of the earth electrode is not to exceed 2 ohms measured in summer. Additional earth rods connecting with the earth loops are to be provided, if needed, to bring down earth electrode's resistance to the specified value.
- D. Alternative Earth Electrode: provide other types of earth electrode that may be used, after approval, including:
1. copper plate(s)
 2. tape mats (strips).
- E. Main earthing bar provide at point of service entrance and at each main distribution MV or LV room, electrical substation, and as described in the Specification or shown on the Drawings, to which all earthing conductors, protective conductors and bonding conductors are to be connected. Two insulated main earthing conductors are to be provided, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. Main earthing bars and conductors are to be bonded to the building steel rebars .
- F. Testing joints (Test Links) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminal or bar and earth electrode.
- G. Protective conductors are to be separate for each circuit. Where protective conductor is common to several circuits, cross-sectional area of protective conductor is to be the largest of the conductor sizes. Selection of sizes is to be in accordance with IEE Regulations.
- H. Protective conductors are not to be formed by conduit, trunking, ducting or the like. Where armoured cable is specified and armour is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the Drawings.
- I. Continuity of Protective Conductors: series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and/or brazing to continuous protective conductors which are to be insulated by moulded materials.
- J. Earth Fault Loop Impedance: for final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on overcurrent occurs within 0.4 seconds, and for final circuits supplying only fixed equipment, earth fault loop impedance at every point of utilization is to be such that disconnection occurs within 5 seconds. Use appropriate tables and present same for approval by the Engineer.
- K. Supplementary Equipotential Bonding: all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable armour are to be connected to nearest earthing terminals by equipotential bonding conductors. Cross-section of protective bonding conductor is not to be less than half that of the protective conductor connected to respective earthing terminal and minimum 4 mm².
- L. Main Equipotential Bonding: main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry/exit of services and main earthing

bar. Where meters are installed, bonding is to be made on the premises side of the meter. Cross-sections of conductors are not to be less than half that of the earthing conductor connected thereto and minimum 16 mm².

- M. Identification: connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labelled in accordance with the Regulations, as follows:

SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE.

- N. Identification: protective and earthing conductors are to be identified by combination of green-and-yellow colours of insulation or by painting bar conductors with these colours, as approved.

- O. Identification: source earthing conductor (or neutral earthing conductor) is to be identified along its entire length by continuous black insulation labelled 'neutral earthing'.

2.3 MATERIALS AND PRODUCTS

- A. Earth Rod: copper clad steel, 16 mm diameter, 2400 mm length, extendible as necessary to obtain required earth resistance. Earth rod is to be complete with couplings, driving stud, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated thereto.
- B. Buried Earth Electrode Loop Conductors: bare annealed stranded copper conductors.
- C. Earth Pit: precast, square or circular section concrete handhole, with cover to metal surroundings, and extending to about 150 mm below top of earth rod. Earth pit is to be provided for each earth rod where connected to an earthing conductor. Cover is to have inset brass plate with inscription 'Earth Pit - Do Not Remove'.
- D. Main Earthing Conductors from Earth Electrode to Main Earthing Bars: annealed stranded copper conductors, PVC insulated as shown on the Drawings.
- E. Earthing Conductors: insulated or bare copper conductor as described in the Specification for the particular application or shown on the drawings
- F. Testing Joints (Test Links): copper or copper alloy, with bolted end connections, disconnectable by use of a tool, and suitably sized for earthing conductors or earth bar connection. Links are to be fixed to porcelain or other approved insulating supports. Contact surfaces are to be tinned.
- G. Protective Conductors: single core stranded annealed copper, PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming part of a multi-core cable, colour coded.
- H. Main Earthing Bar: hard drawn copper, 50 x 10 mm. Earth bar is to be labelled 'Main Earth Bar' and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators. Main earthing bars are to be provided in each transformer substation room, main distribution board room, generator room, MV distribution room, etc. as shown on the drawings.
- I. Protective Bonding Conductors: bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross-sectional area as described in relevant subsections or articles of this section or other sections of the Specification.
- J. Earthing Accessories: copper or copper alloy, purpose made, of approved design, compatible with points of connection, and of adequate cross-section and current carrying capacity. Connectors and clamps are to be bolted type. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys.
- K. Equipotential/Signal Reference Earthing Bar: hard drawn copper, 38 x 6 mm, drilled for connection of conductor every 75 mm and to be supplied with copper alloy bolts, nuts, washers and wall mounting insulators for installation in mechanical rooms and low current rooms.
- L. Bonding of main and signal reference earthing bars and earthing conductors to the building structure rebars is to be through 70 mm² copper conductors connected to the rebars via exothermic welding as shown on the drawings.

PART 3 - EXECUTION

3.1 EARTHING OF DISTRIBUTION BOARDS, PANELBOARDS, LIGHTING INSTALLATIONS AND WIRING ACCESSORIES

- A. Distribution, lighting and power panel boards are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panel boards with respective main distribution board earthing bar.
- B. Socket outlets are to be earthed by protective conductor looped around with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet terminal is to be connected.
- C. Lighting fixtures and other exposed conductive parts of electrical installations, such as switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panel boards.

3.2 MECHANICAL PLANT ROOMS, LABORATORIES AND FIXED MACHINERY

- A. Equipotential earthing bar is to be conveniently located in mechanical rooms, kitchen, laundry and laboratories, and connected to exposed conductive parts of motors, switches and other electrical equipment etc. and to all extraneous non-electrical metallic structures within each room, using copper conductors as shown on the drawings. Conductors are to be securely fixed, recessed in floor grooves or niches, or fixed to walls by appropriate staples. Earth bar is to be securely fixed to building wall with copper or brass saddles.
- B. Earthing bar is to be connected to the internal earth bar of the motor control center/panel or power panel and to the respective main earthing bar (also to building steel reinforcing bar at the nearest column within the room), directly through two test joints by insulated earthing conductors as shown on the drawings.
- C. Motor and other equipment earth terminals are to be connected also by protective earth conductors of each branch circuit to earth terminal/bar at motor control centre, panel or distribution unit.

3.3 ELECTRONIC AND COMMUNICATION EQUIPMENT ROOMS

- A. Separate earth bar is to be provided in each electronic and communication equipment rooms including BMS and building information computer rooms, telephone equipment room, security room, for signal reference earthing of equipment as shown on the drawings.
- B. Signal reference earth bar in each room is to be directly connected to the earth electrode system and bonded to the building steel rebars.

3.4 BUILDING RELATED EQUIPMENT

- A. Nurse call system shielded audio cables are to be grounded at main equipment cabinet only.
- B. Nurse call and Intercom system equipment enclosures are to be connected with a 4 mm² protective earthing conductor run with branch circuit to the nearest earthing point.
- C. Reference Earth panels: are to be provided in critical care, operating and radiology rooms as shown on the Drawings in accordance with ANSI/IEEE 602 and NFPA 70 & 90 publications as applicable and shown on the Drawings. Each room is to be provided with a separate earth reference panel made of galvanised steel and painted/finished to match surroundings and enclosing 38 x 6 mm copper equipotential bar. All exposed conductive structures within the room are to be connected to the room's earth reference panel as shown on the Drawings. Each panel is to include four earthing jack outlets complete with cords as specified below.
- D. Conductive flooring, if any, is to be connected by a minimum of 4 mm² earthing conductor connecting a minimum of 4 points to the nearest equipotential earthing bar.
- E. Telephone exchange is to have separate earth bar connected directly to the earthing electrode system.
- F. Earthing jack outlets are to be building grade to UL and to be provided with 3 m cord, 4 mm² cu/PVC complete with jack and jack/clamp on both cord

ends. Grounding jack outlets in operating rooms shall be flush mounted with satin stainless steel plate.

3.5 GROUND INTEGRITY TESTER (LIM TESTER)

- A. Unit is to be capable of accurately testing the line isolation monitor (LIM) in order to check the integrity of the isolated power system and that the system is properly grounded. The instrument is to be self-powered and not require connection to any outside voltage source. The unit is to be provided with a LCD meter to indicate the system voltage and the test leakage current. The unit is to be designed to withstand accidental exposure of up to 500V. across the probes without damage to the unit when operating in this mode.
- B. Unit is to contain provisions for battery testing.
- C. Enclosure : containing all the electrical components is to be insulated to prevent accidental exposure of test circuit to outside voltage sources. The case is to be constructed of moulded polyester material.
- D. Unit is to be provided with minimum 10 foot calibrated test leads with suitable plug for connection to the isolated system outlets .

3.6 INSTALLATION

- A. Continuity: ensure that complete earthing system is electrically continuous and mechanically secure.
- B. Earth Rods: while siting earth rods, ensure that resistance areas associated with individual rods do not overlap. Earth rods are to be located at a distance greater than 600 mm from foundations of buildings. Where rock is encountered, a hole of sufficient size is to be drilled before lowering the rod. Conductive filler such as Marconite or Bentonite or equal filler that will not corrode, is to be provided around the rod.
- C. Buried earthing conductors are to be laid at a depth not less than 0.8 m from ground surface.
- D. Earthing conductors are to follow shortest path between earth rods and main earthing terminals or bars, and are to run in PVC conduit (duct) fastened to building structure by approved supports and extending 0.2 m above level, and are to be protected against mechanical damage and corrosion.
- E. Protective Conductors: separate protective conductors, which are not part of a cable, are to be fixed on same support or drawn into same conduit as circuit conductors.
- F. Protective Bonding: remove any non-conductive paint, enamel or similar coating at threads, contact points and surfaces and ensure that bonding is made by fittings designed to make secure bonds.
- G. Protection Against Corrosion: protect bolted connections against corrosion either by filling with vaseline or coating with a special anti-corrosion compound and proper capping.
- H. Connections: earth connections are to be readily accessible. If inaccessible earth connection is permitted, approved exothermic welding or brazing technique is to be employed.
- I. Connections: where earth connections between dissimilar metals must be made, use bimetallic fittings and protect by coating with moisture resisting bituminous paint or compound, or by wrapping with protective tape to exclude moisture.

3.7 TESTS ON SITE AND RECORDS

- A. Combined resistance of earth electrodes is to be measured during dry season and checked against specified resistance.
- B. Electrical continuity of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.
- C. Earth fault loop impedance of all circuits is to be measured and checked against calculated impedance figures.
- D. Operation of residual current protective devices is to be checked. E. Records: submit the following:
1. scaled drawings, as-installed, showing actual layout and specification of all components of earthing system
 2. nature of soil and any special earth arrangements etc.
 3. date and particulars of soil conditioning method and agents if used

4. test conditions and results obtained.

END OF SECTION
16452

**SECTION
16470**

**PANELBOAR
DS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to work of this section.
- B. Division 16 "Basic Electrical Requirements" and other sections apply to work specified in this section.

1.2 SUMMARY

- A. This section includes panel boards for distribution and sub distribution of electric power and for protection of circuits, including fixing and supporting materials and materials for termination of feeders, sub circuits and branch circuits.

- B. Types of panel boards and enclosures required for the project include the following: LP: Final branch circuit Lighting Panel board.
PP: Final branch circuit power panelboard. SDP: Sub distribution panel board.
DP: Distribution panel board.

Note 1: Final branch circuit lighting panel boards, and power panel boards for secondary lighting and power distribution are designated with either miniature circuit breaker (MCB) or moulded case circuit breaker (MCCB) protection on sub feeder or branch circuits, as shown on the drawings.

Note 2: Panel boards supplied from emergency source are prefixed with the letter

E. Note 3: Panel boards Equipped with isolating transformers are prefixed with letter I.

- C. Refer to other Division 16 sections " LV Wires/Cables", "Electrical Enclosures, Boxes and Fittings", and "Raceways" required in conjunction with installation of panel boards and enclosures.
- D. Refer to Division 16 section "LV Circuit Breakers" for circuit breaker applications and recommended types and frames for this project.
- E. Refer to Division 16 section "Wiring Devices ".
- F. Refer to Division 15 section "Building Management System" for connection to BMS.

1.3 SUBMITTALS

- A. Product Data: submit manufacturer's data and catalogues on panel boards and enclosures.
- B. Dimensions and contents of each panel board.
- C. Coordinated tabulations of series short circuit combination of circuit breakers.
- D. Wiring Diagrams: submit wiring diagrams for panel boards showing connections to electrical power feeders and distribution branches.
- E. Typical mounting details, labels, tags.
- F. Tests and certificates: submit complete certified manufacturer's type test and routine test records in accordance with the Standards applicable.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: firms regularly engaged in manufacture of panel boards and enclosures, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: a firm with at least 3 years of successful installation experience on projects utilizing panel boards similar to those required for this project.
- C. Codes and Standards:
 - 1. IEC 60439 and IEC 60947.
 - 2. Electrical Code Compliance: comply with applicable local code, regulations and requirements of the authority having jurisdiction, as applicable to installation, and construction of electrical panel boards and enclosures in this project.

1.5 SEQUENCING AND SCHEDULING

- A. Coordinate installation of panel boards and enclosures with civil/architectural program and installation of wires/cables, electrical boxes and fittings, and raceway work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 PANELBOARDS - GENERAL

- A. Schedules on drawings indicate type and requirements of each panel board. These are defined by the following criteria:-
 - 1. type of construction (MCB or MCCB), referring to type of branch circuit breakers required.
 - 2. voltage, number of phases and wires
 - 3. branch circuit breaker trip rating and wire size
 - 4. main circuit breaker trip rating and frame size (maximum continuous rating) for MCCB
 - 5. short circuit interrupting capacity (IC) in kA
 - 6. special arrangement or provisions.
- B. Rated insulation voltage is to be in accordance with the respective Standards.
- C. Panel boards are to be totally enclosed, dead front type, protection code IP42 for indoor installations and IP 55 for outdoor installations, in accordance with IEC 60529 and are to be factory designed and assembled.
- D. Earthing bar is to be provided in every panel board and to be half size the phase bus bars.

- E. Neutral bar is to be provided in every panel board and to be full size as per the phase bus bars.
- F. Protection is to be fully rated through-out the systems.
- G. Circuit breakers are to be non-fused type.
- H. Circuit breaker arrangement: panel boards are to have one main incoming circuit breaker or switch and the required number of branch circuit breakers, arranged as shown on the Schedules, including spare circuit breakers and spaces for future expansion. Three-phase panel boards are to be designed for sequence phase connection of branch circuit devices.
- I. Branch circuit numbering: on 3-phase panel board schedules, circuits 1 and 2 are to be connected to red (R) phase, 3 and 4 to yellow (Y) phase, 5 and 6 to blue (B) phase, etc., to conform with branch circuit numbering shown on the Drawings.

- J. Connection to Building Management System (BMS): coordinate with the BMS supplier and provide all necessary interface devices, instruments, dry contacts for connection of all required points to the BMS as specified or indicated in the BMS schedules.

2.3 PANEL BOARD ENCLOSURES

- A. Type: general purpose type, suitable for relevant ambient conditions, flush or surface mounted as shown on the Drawings, comprising box, trim or trim and door to approved manufacturer's standards and sizes.
- B. Construction: recessed mounting box with multiple knockouts, trim and doors where required, are to be electro-galvanized sheet steel of gauges not less than specified in accordance with the Standards, minimum 1.5 mm thickness. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the Standards, but are not to be less than 100 mm on all sides. Enclosure is to have pre designed angles or threaded end studs to support and adjust mounting of interior panel board assembly.
- C. Trims are to cover and overlap front shield, covering all terminals and bus compartments, to form a dead front panel. Trims are to be fixed to cabinet/box by adjustable quarter-turn clamps engaging flange of box (use of screws engaging holes in flange box is not acceptable). Screws where used are to be oval-head, countersunk and flush. Trims for flush mounted panel boards are to overlap box and front shields by at least 20 mm. Trims for surface mounted panel boards are to be exactly sized to form flush fit to box.
- D. Doors are to have piano type concealed hinges integral with trim, and flush combination cylinder lock and catch. Doors over 1000 mm high are to have vault-type handle and multiple point latch mechanism. Locks are to be flush and keyed alike.
- E. Finish: inner and outer surfaces of cabinet/boxes, trims, doors etc. are to be cleaned, phosphatized, chrome passivated and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, aging and corrosion and of standard grey colour to the approval of the Engineer.
- F. Directories under glassene with directory frame, or an approved alternative durable arrangement, are to be provided on inside face of doors, or in metal label holders when trim without doors is specified. Directories are to be typed to identify panel boards and clearly indicate circuit number and description of load.
- G. Outdoor enclosures are to be heavy duty sheet steel cabinets, minimum 1.5 thick, fully weatherproofed (IP 55), without knockouts, but with removable sealed/gasketed bottom gland plates and gasketed doors.

2.4 BUSBARS

- A. Type: one piece, 98% pure electrolytic copper, based on a total maximum operating temperature of 90 deg. C at full continuous rating (40 °C temperature rise above 50 °C ambient). Bolted or clamped contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminium is not to be used for bus bars or panel board parts.

- B. Design: bus bars are to be shrouded/insulated and rigidly designed so that branch circuit devices can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping. Busing is to be full size without reduction. Busing and blank plates are to allow installation of future circuit devices, where indicated on the Drawings.
- C. Rating: busbar rating is to be at least equal to main circuit breaker frame size. Where no main circuit breaker is required, busbars are to have main lugs or disconnect switch, and to have nominal rating not less than 1.25 times the upstream circuit breaker trip rating.
- D. Short-Circuit Duty: busbars are to carry maximum short-circuit duty of main protective device, which is to be at least maximum short-circuit at point of application for one second, without showing any signs of degradation.
- E. Terminals and connections are to be anti-turn, solderless screw-pressure type. Screws and bolts used for making copper/copper connections are to be hard copper alloy with lock washers (riveted bus connections are not acceptable).
- F. Neutral bar is to be solid and fully insulated from cabinet or box. One solderless box type set- screw connector is to be provided for neutral wire of each branch circuit and one bolted clamp-type connector or anti-turn lug with set-screw for main incoming neutral wire. Neutral is to be fully sized and rated as for phase busbars.

- G. Earthing bar is to copper, brazed to panel board cabinet, with bolted pressure connector for main conductor and one set-screw-type tunnel terminal for each outgoing conductor, to provide secure and reliable contact with all metal parts and enclosure.

2.5 DISTRIBUTION PANELBOARDS (DP)

- A. DP: to have a rated insulation voltage of 1000 V, rated operational voltage of 600 a.c. or d.c., and to be conforming to IEC 60439:, suitable for ratings of main breaker or switch and bus bars ranging from 150 A to 1200 A, 3-phase, 4-wire (or 3-wire where specifically indicated), suitably and orderly arranged for any selected combination of branch MCCBs ranging from 100 A to 1200 A frame size and short-circuit interrupting ratings as shown on the Drawings.
- B. Construction: sheet steel, minimum 1.5 mm thick for cabinet/box and minimum 2 mm thick for trim or trim and door. Fronts are to be single or twin covers to shield circuit breakers, terminals and live ends.
- C. Size and construction: of the distribution panels that are equipped with provision for the kWhr meters should be coordinated with the electrical authority and ensure their approval.
- D. Interior of panel board is to be pan assembly consisting of galvanized sheet steel chassis minimum 2 mm thick, folded, flanged and reinforced, with bus bars vertically arranged and mounted on moulded insulators.
- E. Moulded insulators are to have minimum temperature rating of 130 deg. C and insulation grade of 3.5 kV for one minute.
- F. Circuit breakers are to be mounted in twin arrangement (except for larger circuit breakers) and bolted rigidly to copper cross and centre bus connectors.

2.6 FINAL BRANCH CIRCUIT, AND POWER PANELBOARDS - GENERALLY

- A. Arrangement: to comprise set of homogeneous branch circuit breakers with unified profile and base, and one main circuit breaker. Single and multi-pole circuit breakers or other devices are to occupy modular spaces. Accommodation of contactors and split-bus arrangement or other devices is not to change regularity of standard box width.
- B. Indoor Enclosure: sheet steel, minimum 1.0 mm thick for box/cabinet and minimum 1.5 mm thick for front shield, trim and door. Fixings for flush trim are to be adjustable to allow for mis-alignment between box and wall surface. Wiring spaces (gutters) are to be at least 100 mm wide. Larger gutters are to be provided where tap-off insulated split connectors are required. Knockouts are to be provided in top or bottom of enclosures and are to provide a neat and uniform conduit/cable terminal arrangement.

2.7 FINAL BRANCH CIRCUIT, AND POWER PANELBOARDS - TYPE MCCB

- A. Type: to have a rated insulation of 750 V and rated operation Voltage of 600 V a.c. and 240 V d.c., lighting and distribution type (lighting and appliance type, to NEC), single-phase and neutral (SPN) or 3- phase and neutral (TPN), with bolted 1, 2, or 3-pole MCCBs on branch circuits and 2, 3 or 4-pole MCS on main incoming.

- B. Branch circuit breakers are to be 1, 2 or 3-pole, rated 100 A frame size, with trip ratings between 15 A and 100 A, and compatible ICs, selected from normal (D) or high-break (MA) as indicated in section "LV Circuit Breakers" of this specification.
- C. Assembly: busbars are to be rigidly fixed on moulded insulators to back pan in vertical arrangement.
Branch circuit breakers are to be bolted in twin arrangement to rigid copper cross and centre bus connectors. Back pan assembly is to be removable and fixed to four threaded studs integral with cabinet.

2.8 FINAL BRANCH CIRCUIT PANELBOARDS - TYPE MCB

- A. Type: to have a rated insulation voltage of 600 V and a rated operational voltage of 440 V.
- B. Internal Assembly: to comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with DIN rails in horizontal arrangement for SPN panels, and in vertical arrangement for TPN panels. Assembly is to be

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complete with neutral terminal block, earthing bar and one piece insulated bolt-on/comb-type phase busbars. Busbars

are to be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards. Panel boards are to comply with BS 5486 Part 12.

- C. SPN type panel boards are to be, single-phase and neutral, with MCBs on branch circuits and MCS main incoming.
- D. Single pole and double pole MCBs, are to have trip ratings between 6A and 50A, with ICs as required in the Schedules.
- E. TPN type panel boards are to have MCBs on branch circuits and 3 or 4-pole MCB, MCCB or MCS as main incoming, as shown on the drawings.
- F. Triple-pole branch circuit breakers are to have trip ratings between 5 A and 100A, with IC as required in the Schedules.
- G. TPN type panel board main circuit breakers/switches are to be MCB or MCCB, 100A, continuous current rating with trip range 25A to 100A, or 250 A MCCB with trip range 70A to 250A, normal (N) or high-break (H) duty with/without RCD as shown on the Drawings. MCS where indicated, may be used with frame size up to 225A.

2.9 FINAL BRANCH CIRCUIT PANELBOARDS; SPLIT-BUS MCCB/MCB TYPES

- A. Assembly is to be as specified for MCB or MCCB type of branch circuit panel board , but with split-bus arrangement, part of which is controlled by in-built sub main contactor or circuit-protective device for group control of a number of branch circuits. Panel board is to have main circuit breaker for protection and isolation.
- B. Contactors: provide 2 or 3-pole, electro-magnetic type, class AC 5b or AC5a to IEC 60947-4, designed to withstand large initial currents of tungsten lamp loads or discharge lamp loads respectively, and rated not less than overload setting of protective device upstream.

2.10 BUILDING ISOLATION POWER PANELS (IPP's)

- A. In general panels are to be factory wired and tested and include a shielded low leakage isolating transformer, primary and secondary circuit breakers, a line isolation monitor audible and visual alarms and metering of the line isolation monitor and complete with necessary facilities for connection to the respective remote indicator panel.
- B. Circuit breakers are to comply with the section LV circuit breakers of the specifications. All transformer secondary and branch circuit breakers are to be 2 poles. Panels are to have secondary circuit breakers as scheduled.
- C. Enclosure is to be flush mounted unless otherwise noted on the drawings. Units 5 k VA and smaller shall have a maximum depth of 21cm.
- D. Panels are to be flush trim type; cover shall be brushed stainless steel and shall contain a hinged door with keyed lock to provide access to the circuit breakers, line isolation monitor and its provisions for testing.
- E. Entire section behind the hinged door is to be of dead front design. All hinges are to be of the concealed type.

- F. Panel and transformer is to be so designed that the heat generated by the transformer under full load conditions is not to affect the normal operation of the circuit breakers and ground detector.
- G. Panels are to also contain an equalizer earth bar to which all earthing jacks and grounding terminals from all sockets are connected. In addition, the equalizer earth bus is to contain a sufficient number of internal lugs to allow connection of earth leads from all permanently located metal objects in the patient care area. Panel is to comprise 4 Nos earthing jack outlets, complete with cords as specified in section 16452.

2.11 LOW LEAKAGE ISOLATING TRANSFORMER

- A. Transformer is to be wound with an electrostatic shield between the primary and secondary windings, which is to be grounded to the enclosure. The electrostatic shield is to be of such design that it will prevent direct shorting of the primary winding to the secondary winding, and reduce the coupling of harmonic distortions between the primary circuit and secondary circuits.
- B. Leakage current to ground from the transformer secondary winding is not to exceed 10 microamperes.
Regulation to be certified not to exceed 2.6% at 0.8PF at 20Deg. C above the full load continuous operating temperature in accordance with NEMA ANSI Standards.
- C. Transformer is to be single phase, 50HZ with 220 volt primary and 220 volt secondary voltages. Class H rated insulation shall be limited to manufacture of the transformer, and the temperature rise is not to exceed 55Deg. C above ambient temperature of 50 deg C under full load conditions when tested in accordance with NEMA-ANSI Standards. Transformers shall have a Class H insulation system.
- D. Core And Coils are to be internally isolated from the enclosure by means of a suitable vibration dampening system.
- E. Noise Level is not to be in excess of 25 decibels for units up to 5 kVA and 45 decibels for larger units.

2.12 LINE ISOLATION MONITOR

- A. Line isolation monitor (LIM) is to be of the dynamic type capable of detecting all combinations of capacitive and resistive faults, including balanced, unbalanced and hybrid faults. A meter is to provide continuous visual indication of the total leakage current in the monitored system.
- B. Line isolation monitor (LIM) is to incorporate a single push-button which, when depressed, will render a complete test of the entire system including meter, lights, audible alarm, and trip circuits.
- C. Line isolation monitor (LIM) is to be fused. The leakage which the LIM contributes to the isolating system is not to exceed 5 microamperes. Under a zero fault impedance test the measurable leakage contributed by the LIM is not to exceed 300 microamperes. The alarm point is to be set at not less than 1.7 milliamp meter furnished with the LIM shall read from zero and be calibrated in microamperes.
- D. Ground detector is to indicate danger when the total hazard index exceeds 2 milliamps

2.13 REMOTE INDICATOR PANELS

- A. Remote indicator panels are to be flush mounted and have a brushed stainless steel front trim. Panels are to duplicate all audible and visual alarms and metering of the line isolation monitor. They are to be provided with a mute switch to silence the audible alarm.
- B. Remote indicator panels are to be provided at the department nurse station to monitor isolated power panels within the department.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which panel boards and enclosures are to be installed, notify Engineer and correct conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.2 INSTALLATION OF PANEL BOARDS

- A. Install panel boards and enclosures as indicated, in accordance with manufacturer's written instructions, requirements of applicable standards of Installation, and in compliance with recognized industry practices to ensure that products fulfil requirements.
- B. Align, level and securely fasten panel boards to structure, ensuring that they are permanently and mechanically anchored.
- C. Fix surface mounted outdoor panel boards at least 25 mm from wall ensuring supporting members do not prevent flow of air.
- D. Do not use connecting conduits to support panel boards. E. Close unused openings in panel board cabinets.
- F. Do not install interior of panel boards in cabinets until all conduit connections to cabinet have been completed.
- G. Wiring inside panel boards to be neatly arranged, accessible and strapped to prevent tension on circuit breaker terminals. Tap-off connections on a riser feeder are to be split and bolted type, fully insulated.
- H. Trim: fix plumb and square prior to painting. Fix trim for flush mounted cabinets flush with wall surface finish.
- I. Protection: treat concealed surfaces of recessed cabinets with heavy field application of waterproof compound prior to installation.
- J. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in the approved standards.
- K. Fill out panel board's circuit directory card upon completion of installation work in a proper and neat manner acceptable to the Engineer.

3.3 EARTHING

- A. Provide equipment earthing connections for panel board enclosures as indicated, and as recommended in the Regulations and Codes applicable. Refer to Section "Earthing".

3.4 FIELD QUALITY CONTROL

- A. Prior to energization of electrical circuitry, check all accessible connections to manufacturer's tightening torque specifications.
- B. Prior to energization of panel boards, check with earth resistance tester phase-to-phase and phase-to-earth and neutral to earth insulation resistance levels to ensure requirements are fulfilled. Record all readings, using 500 V megger for equipment on 240V systems, 1000V megger for equipment on systems up to 600V for 1 minute with CBs in open position.
- C. Prior to energization, check panel boards for electrical continuity of circuits, and for short-circuits. D. Ensure and test earth continuity and resistance in accordance with Section "Earthing".

- E. Carry out circuit breaker tests as required in Division 16 Section "LV Circuit Breakers" and as required by the Engineer.
- F. Routine tests on site are to be carried out, in accordance with the Standards, on all panel boards assembled from standardized components of the manufacturer outside the works of the manufacturer.

3.5 ADJUSTING AND CLEANING

- A. Adjust operating mechanisms for free mechanical movement.
- B. Touch-up scratched or marred surfaces to match original finishes.

3.6 DEMONSTRATION

- A. Subsequent to wire and cable hook-ups, energize panel boards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION
16470

**SECTION
16476**

**LV CIRCUIT
BREAKERS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to the work of this section.
- B. Division 16 "Basic Electrical Requirements" and other sections apply to work of this section. C. Division 16 "Switchboards" and "Panel boards" sections.
- D. Division 16 "LV Wires and Cables" Section.

1.2 SUMMARY

- A. Extent of Low Voltage (LV) circuit-breaker (CB) work is indicated by drawings and schedules. B. Types of circuit breakers in this section include the following:

- 1. Power Air Circuit Breakers, (PACB's)
- 2. Moulded case circuit breakers (MCCB's).
- 3. Miniature Circuit Breakers (MCB's)
- 4. Moulded case switch (MCS)

1.3 SUBMITTALS

- A. Product Data: submit manufacturer's product data including frame size (continuous current rating), short circuit interrupting ratings, special and regular features of mounting , trip rating and illustrated relay features etc. as required by the Engineer and installation instructions for each type of circuit breaker.
- B. Wiring Diagrams: submit wiring diagrams for circuit breakers and accessories showing connections to electrical power feeders and associated equipment. Differentiate between portions of wiring, which are manufacturer-installed, and portions, which are field-installed.
- C. Certification: submit certified type test and routine factory test data, which indicates current- interrupting ratings for each circuit breaker.
- D. Protection coordination: submit complete network study showing proper selection of circuit breakers characteristic time-current curves that will achieve discrimination under fault conditions between down stream and up-stream circuit breakers to and including power company's source protection at the substations.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: firms regularly engaged in manufacture of circuit breakers of types, ratings, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: firm with at least 3 years of successful experience on projects utilizing circuit-breaker devices similar to those required for this project.

C. Codes and Standards:

1. Electrical Code Compliance: comply with applicable local electrical code requirements of the authority having jurisdiction, as applicable to construction and installation of circuit breakers.
2. IEC Compliance: comply with IEC 60947-2 for power and molded-case circuit breakers, and IEC 60898 for miniature circuit breakers.
3. Testing Laboratory Compliance: comply with applicable Testing Authority requirements in country of origin, which apply to construction and installation of circuit breakers of types specified.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver circuit breakers and components in factory-fabricated type containers or wrappings, which properly protect devices from damage.
- B. Store circuit breakers in original packaging and protect from weather and construction traffic.
Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.
- C. Handle circuit breakers carefully to prevent physical damage to CBs and components. Do not install damaged CBs; remove from site and replace damaged devices with new.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 CIRCUIT BREAKERS

- A. General: except as otherwise indicated, provide circuit breakers and ancillary components, of types, sizes, ratings and electrical characteristics indicated, which comply with manufacturer's standard design, materials, components, and construction in accordance with published product information, and as required for a complete installation which shall be subject to approval or rejection of the Engineer.
- B. Power Air Circuit Breakers (PACBs) , Insulated Case
 - 1. Type: encased in steel structure, air ventilated, air break for normal operation at maximum temperature within enclosure at point of application, tested to approved standards, manually operated for normal functions, and automatically tripped under over current conditions. Trip power is to be derived from main power circuit, with sufficient tripping energy to reliably trip circuit breaker. Fixed mounted circuit breaker is to be rear connected.
 - 2. Construction: manually and electrically operated, as shown on the Drawings, with two-step spring charged, stored energy mechanism, quick-make, quick-break type, electrically and mechanically trip-free, to prevent maintaining circuit breaker closed against over current condition whether under manual or automatic operation. Electrically operated circuit breakers are to have integrally mounted spring charging motor mechanism automatically recharged upon closing.

Both manually

or manually and electrically operated circuit breakers are to have mechanical built-in charging lever and are to include open and close direct acting push buttons. Stored energy provision is to allow open/close/open sequence of operation without use of external energy. Safety feature is to allow discharging stored energy without closing circuit breaker. Circuit breaker is to have arc quenching device on each pole and replaceable arcing contacts.
 - 3. Control power for electrically charged, CB and/or for shunt and under voltage trip devices, where required, is to be 120V ac obtained from in-built MDB control power transformer, connected and fused on bus-side.

4. Rating: 3 or 4 pole, 750V rated insulation voltage 600 V rated operational voltage, with continuous current rating (frame size) as shown on the Drawings, ranging between 630 A and 4000 A (630, 800, 1000, 1250, 1600, 2000, 2500, 3200, and 4000 A), fully rated (100%) for service under worst site conditions. Breakers are to be rated for a symmetrical rms service short-circuit breaking capacity as shown on the Drawings, to IEC 60947-2 sequence II (rated service short-circuit breaking capacity) at specified voltage and frequency, to meet IEC 60947-2, sequence I, II, III and IV tests, utilisation category B, tested in an enclosure substantially the same as the enclosure in which they are to be installed.
5. Trip unit: to be totally enclosed, programmable, solid state device, interchangeable for compatible frame sizes, pluggable into front of circuit breaker, tamper-proof and with transparent, sealable cover. Trip unit is to measure sinusoidal and non-sinusoidal current wave forms (fundamental to thirteenth harmonic) by continuously sampling each phase through out every cycle. Trip unit is to be direct acting trip device, current transformer operated, with flux transfer shunt trip that requires no external power. It is to have adjustable current setting (0.5 – 1.0 times trip unit rating) with adjustable long-time delay, short-time pick-up and short-time delay, earth-fault pick-up and time delay instantaneous over current pickup. Current setting range is to be by means of replaceable trip-units within the maximum frame size rating. Once removed, circuit breaker is to remain in the trip-free position. Earth-fault trip is to be adjustable, range 10% to 60% of normal current rating of the circuit breaker and a maximum of 1200A, with adjustable time delay between 0.1 and 0.5 seconds. Short time delay is to be adjustable in steps, 2 - 9 times current setting, with pre-settable or adjustable time band having maximum

delay of 0.3 to 0.5 seconds.

Instantaneous trip is to be adjustable in steps at least 2 – 13 times the trip unit rating. Over-ride protection is to allow full sensitivity up to interrupting capacity of circuit breaker.

6. Trip Unit Status Display: is to indicate in words the status of normal breaker operation, long time over current pick up, instantaneous time over current trip, short time over current trip, ground fault trip. Unit shall have integral resettable counter to count long time, short time, instantaneous and ground fault trips.
7. Position Indicators: to be positive with trip indication target. Target indicator is to be mechanical and is to give indication even when control power has been lost.
8. Circuit breaker accessories are to include the following:
 - a. padlocking or key locking provisions for all positions (disconnected, test, connected, closing blocking, open)
 - b. overload, short-circuit, ground fault trip LEDS
 - c. trip indicator and reset button
 - d. operations counter
 - e. on/off pilot lights
 - f. shunt trip coil and closing solenoid for remote control.
9. Auxiliary Contacts: to include N.O. and N.C. contacts on switchgear as required, plus 2 N.O. and 2 N.C. spare contacts.
10. Trip Unit: is to have inputs from conventional potential transformers for every phase.

Current sensors transformers for every phase. Current sensors shall be encased in epoxy filled plastic housing to protect against damage and moisture and shall be integrally mounted in breakers.
11. Neutral Current Transformer: is to be provided on the neutral conductor of each main, tie or outgoing circuit having earth fault protection. Rating and characteristics of the neutral current transformer are to be suitable for proper operation of the earth fault protection system.
12. Electrical Interlock: if electrical interlock is required between power air circuit breakers, the mechanical closing button of the circuit breaker is to be disabled in the connect position and an additional electrical push button is to be provided for closing of the circuit breaker through the breaker's shunt close coil. The electrical interlock is to be provided on both the shunt trip and close coils of the circuit breaker in order to perform simultaneous tripping and inhibit closing functions on the interlocked breaker.

C. Moulded Case Circuit Breakers (MCCBs)

1. Type: totally enclosed, moulded case, constructed from high quality, high temperature resistant, tropicalized, moulded insulating materials designed for normal operation at 70°C within enclosure to approved standards, provided with quick-make, quick break, trip free switching mechanism, operated by front toggle type handle mechanism for manual operation of main contacts in addition to automatic operation under over current conditions. Tripping to be indicated by handle automatically assuming a middle position between manual on and off positions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Ampere rating is to be clearly visible. All terminals are to be box lug or clamp type with set screws suitable for copper or Aluminium conductors contacts. Contacts are to be non-

- welding silver alloy with arc quenching metallic devices of approved construction.
2. Circuit Breaker Trip Units: unless otherwise specified or shown on the Drawings, circuit breakers below 400 A frame size, are to be non-current limiting thermal-magnetic type, having bi-metallic inverse time delay over current element for small overloads and instantaneous magnetic over current trip element for operation under short-circuit conditions on each pole. Circuit breakers 150 A and larger are to have adjustable instantaneous trips. Circuit breakers 400 A and larger are to have electronic trip unit.
 3. Switching Mechanism: quick-make, quick-break type, with positive trip-free operation so that contacts cannot be held closed against excess currents under manual or automatic operation. Contacts are to be non-welding silver alloy with approved arc-quenching devices of metallic grid construction.
 4. Thermal over current trips are to be compensating type to allow for ambient temperature higher at breaker than at protected circuit or device. Compensation is to be applicable between 25 and 50 deg. C. In case of adjustable thermal settings, range of adjustment is not to exceed maximum trip rating shown on the Drawings/Schedules.
 5. Trip current rating (Amps) indicates nominal maximum rating at which overload element is set to operate.
 6. MCCB's For MDBs: non-current limiting, type, 750 V rated insulation voltage, 600V.a.c. and 250V dc. rated operational voltage, utilization Category B, fully rated (100%) with continuous duty at site conditions, and with frame size and interrupting capacity to IEC 60947-2, sequence II (rated service short-circuit breaking capacity), and maximum trip rating as shown on Drawings. Circuit breakers at specified voltage and frequency are to meet IEC 60947-2 test sequences I, II, III and IV.
 7. MCCB's application for LPs, PPs & DP's are to be of same characteristics as described above for the MCCB's for MDB's, except their short circuit interrupting capacity which is to be in compliance with Sequence III to IEC 60947-2 (ultimate rating).
 8. Tripped Position: when tripped automatically by over current condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between

on and off positions.

9. Interchangeable Trips: circuit breakers 250 A frame and larger are to interchangeable trip unit type.
10. Sealing: circuit breakers with non-interchangeable trip units are to be sealed. Circuit breakers with interchangeable trip units are to have trip unit covers sealed to prevent tampering.
11. Electronic trip units, applicable to circuit breakers 400 A frame size and larger, are to be solid state with long time delay settings between 0.5 and 1.0 times maximum trip rating, short time delay range of 3 to 10 times maximum trip rating with a maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units are to be insensitive to changes in ambient temperature between -20 and +55 deg. C. Earth fault protection is to be built into trip unit where specified, adjustable between 0.2 and 0.6 of normal phase current pick-up with maximum time-delay of 0.2 seconds, with integral current transformers. Push-to-trip button is to be provided on cover for testing the trip unit.
12. Accessories: circuit breakers are to be designed to accommodate standard attachments including shunt-trip, under-voltage release, combined auxiliary and alarm switches, and electrical operator to any circuit breaker of rating (frame size) 100 A and over. Padlocking and key-lock devices are to be provided where shown on the Drawings.
13. Residual Current Operated Earth Leakage Trip Devices (RCDs): provide add-on or built-in earth leakage accessories, where required and as shown on the Drawings. Protection against earth leakage current, in addition to over current and short-circuit protection, is to be in accordance with the Regulations. Trip current sensitivity on breakers for branch circuits is to be 30 mA maximum; and for main breakers trip ratings are to be as shown on the Drawings or as specified in Section "Earth-fault Protection ". Circuit breakers are to include current transformer with tripping coil assembly, test button and trip free mechanism to ensure circuit breaker cannot be held closed against earth faults.

D. Miniature Circuit Breakers (MCBs)

1. Type: thermal magnetic non-adjustable type, tested in accordance with IEC 60898 .
2. Voltage Rating: 440 V rated insulation voltage and 250 rated operational voltage.
3. Minimum Short-Circuit Breaking Capacities are to be as follows:
6 - 100 A MCB : 10, 15 kA 20 or 25 kA at 220/380 V a.c. as required in the panel boards schedule drawing
4. Construction: MCB's are to be tropicalized for operation at ambient temperatures up to 70 deg. C within panel board enclosure and humidities up to 95%, and are to be constructed from high quality, high temperature, moulded insulating materials. Guaranteed duties and characteristics are to be submitted for temperatures above 50 deg. C. MCBs and combinational devices are to be modular, of unified profile and mounted to a standard DIN rail.
5. Operation: under overload conditions, thermal tripping is to provide close protection of insulated conductors. Under short-circuit conditions, magnetic trip is to operate at 5 - 10 times normal rated current (type 3 characteristic) unless otherwise indicated. Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milli-seconds.
6. Ratings: preferred rated currents are to be 6, 10, 15, 20, 25, 30, 40, 50, 60, 80 and 100 A, calibrated at 50 deg. C, available as 1, 2, 3 and 4-pole circuit breakers. Derating above 40 deg. C is not to exceed 1% per deg. C, and loading is not to exceed 70% of circuit breaker rating.
7. Residual current devices for earth leakage protective circuit breakers may be add-on devices, or built-in and integral with the standard miniature circuit breaker. Non-adjustable sensitivities of

10 mA, 30 mA, 100 mA and 300 mA are to be available for all ratings of 2-pole and 4-pole circuit breakers.

8. Auxiliaries, where required or shown on the Drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units, which are to be modular additions to the circuit breakers.

E. Moulded Case Switch (MCS)

1. Moulded Case Switch: non-automatic on/off switching device of equal construction to equivalent circuit breaker, having no over current or fault protective elements, but marked with maximum current withstand and voltage rating,

F. Motor Circuit-Protector

1. Magnetic only type circuit breaker with adjustable current sensing trip coil in each of the 3-poles to provide short circuit protection, manually operated for normal switching functions and automatically operated under short circuit conditions.
2. Motor Circuit Protector: to be a recognised component under UL 489 and comply with the applicable requirement of IEC 60947-2.
3. Rating is to be 750V rated insulation voltage and 600V rated operational voltage with continuous current rating selectable between 3 A and 400 A as shown on drawings, fully rated for service under worst site conditions and with trip settings between 3 and 10 times continuous ratings. Motor circuit protectors to be rated for a service short circuit breaking capacity as required at the motor control centre. Back-up fuses may be added for short circuit protection; coordinated with the magnetic trip element to effect tripping of all poles of the circuit breaker, where short circuit currents are above the normal magnetic tripping range indicated. Fuses are to be of the current limiting type.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which circuit breakers are to be installed and evaluate conditions detrimental to proper completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner .

3.2 INSTALLATION OF CIRCUIT BREAKERS

- A. Install circuit breakers and accessories as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with requirements of Local Regulations and Standards, and applicable approved or recommended "Standard of Installation" pertaining to installation of circuit breakers and general wiring practices.
- B. Coordinate with other work, including electrical wiring work, switchboards, panel boards as necessary to interface installation of circuit breaker work with other work.
- C. Fasten circuit breakers without causing mechanical stresses, twisting or misalignment being exerted by clamps, supports, or cabling.
- D. Set field-adjustable circuit breakers for trip settings as indicated in accordance with an approved system coordination scheme, subsequent to installation of units.
- E. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques of compatible standards.

3.3 ADJUST AND CLEAN

- A. Inspect circuit-breaker operating mechanisms for malfunctioning and, where necessary, clean and adjust units for free mechanical movement.

3.4 EARTHING

- A. Provide equipment earthing connections for circuit breakers as indicated. Tighten connectors to comply with tightening torques specified in manufacturers standards or compatible international standards to assure permanent and effective earthing.

3.5 FIELD QUALITY CONTROL

- A. Upon completion of installation and after circuitry has been energized, demonstrate capability and compliance of system with requirements. Where possible, correct malfunctioning units on site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting. Testing and retesting at no cost to Employer.
- B. Circuit Breakers: tests are to include operation of every circuit breaker manually. Check automatic operation of selected circuit breakers, as required by the Engineer, by applying necessary short-circuit, overload and earth leakage current for tripping circuit breaker as applicable and compare

with manufacturer's data/characteristic curves. Measure and report ambient temperature inside enclosure.

1. Primary Injection Tests: provide primary injection portable test equipment to test time- delay characteristics of circuit breakers by simulating an overload or fault condition. Measure and record all test results and ambient conditions and compare with manufacturer's data.
2. Instantaneous Trip Elements: test instantaneous trip by high current primary injection, using high-current primary injection test-sets and report all readings.

END OF SECTION
16476

**SECTION
16481**

**MOTOR
CONTROLLERS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to work of this section.
- B. Requirements of the following Division 16 sections apply to work specified in this section:
1. "Basic Electrical Requirements"
 2. "Motor Control Centres"
 3. "Electrical Cabinets, Boxes and Fittings"
 4. "Circuit and Motor Disconnects"
 5. "LV Circuit Breakers"
 6. "LV Wires and Cables"

1.2 SUMMARY

- A. This section includes low-voltage motor controllers (starters) as indicated by drawings and schedules. B. Types of motor controllers specified in this section include the following:
- Fractional HP manual.
 - Across the Line Magnetic.
 - Combination Starter.
 - Solid-state reduced voltage.
 - Auto-transformer reduced voltage.
 - Wye-delta reduced voltage.
 - Variable speed drive
- C. Work of this section includes wires/cables, electrical cabinets, boxes and fittings, as specified in Division 16 sections, and used in conjunction with motor controllers.
- D. Refer to applicable Division 16 "LV Wires and Cables", "Electrical Raceways", and "Electrical Cabinets, 'Boxes and Fittings" Sections for requirements in connection with motor controllers.
- E. Refer to applicable section in Division 15 for requirements in connection with system control and operation.

1.3 SUBMITTALS

- A. Product Data: submit manufacturer's data and installation instructions on motor controllers. Include dimensions, ratings and data on features and components.
- B. Shop Drawings: submit shop drawings of motor controllers showing accurately scaled equipment, locations and spatial relationships to associated motors and equipment.

- C. Wiring Diagrams: submit power and control wiring diagrams for motor controllers showing connections to electrical power panels, feeders, and equipment. Differentiate between portions of wiring which are manufacturer-installed and portions which are field-installed.
- D. For Variable Speed Drives: Submit manufacturer's performance data including dimensional drawings, customer connection drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VSDs FLA rating, certification agency file numbers and catalog information.
- E. Certified Reports: submit field tests and observations specified in "Field Quality Control" in this Section.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: firms regularly engaged in manufacture of motor controllers of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: firm with at least 3 years of successful installation experience with projects utilizing motor controller work similar to that required for this project.
- C. The supplier shall have a permanent representative office with a trained and skilled support staff, in order to prove his commitment for local support and to provide a channel for communication. The local representatives shall be easily accessible and shall be able to have a technical team at the site within 24 hours' notice, 7 days of the week.
- D. The engineers employed by the supplier's regional office shall be certified by the manufacturer and provide start-up service including physical inspection of the drive, connected wiring and final adjustments, to ensure that the Controller / VSD meet the required performance.
- E. The supplier shall be able to give basic drives training to the Customer's engineers, preferably on the site but anyway, in the country where the customer's site is. The training shall, as a minimum, include system concepts and basic troubleshooting. The supplier shall also be capable of solving most Controller/ VSD problems quickly. He shall also have a 24 hour support from the drives' factory, to avoid any delays during service or repair work on the site.
- F. The manufacturer shall be able to offer commissioning and certification of the installation of the drive to be done by the local office.
- G. The most common spare parts like fuses, IGBTs as well as main control and IO boards shall be available in 48 hours from the notification through a regional service center of the supplier. The more rarely used spare parts should be available in maximum 5 days on site.
- H. Codes and Standards:
1. IEC Compliance: comply with IEC 60947 – 1 & 4 for contactors, IEC 60439-1 Low Voltage Switchgear and Control Gear Assemblies, and IEC 60292 - 1, for low voltage motor starters.
 2. Electrical Code Compliance: comply with applicable local Electrical Regulations or Code requirements of the authority having jurisdiction .
 3. NEMA ICS2, "Industrial control devices, controllers and assemblies".

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver motor controllers and components properly packaged in factory-fabricated type containers.
- B. Store motor controllers and components in original packaging and in a clean dry space; protect from weather and construction traffic.

- C. Handle motor controllers and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

1.6 SEQUENCING AND SCHEDULING

- A. Coordinate with other electrical work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of motor controllers with other work.
- B. Sequence motor controller installation work with other work to minimize possibility of damage and soiling during remainder of construction period.
- C. Coordinate installation with driven equipment and remote control systems including any interfacing, if required, with central control and monitoring system.

1.7 MAINTENANCE

- A. Maintenance Data: submit maintenance data and parts list for each motor controller and component; including "trouble shooting" maintenance guide. Include that data, product data and shop drawings in a maintenance manual; in accordance with requirements of the general and special conditions of contract.

- B. Maintenance Stock, Fuses: for types and ratings required, furnish additional fuses, amounting to one unit for every 5 installed units, but not less than 2 units of each.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 MOTOR CONTROLLERS –GENERAL

- A. Except as otherwise indicated, provide motor controllers and ancillary components which comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for a complete installation.
- B. Coordinate the features of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, the duty cycle of the motor, drive, and load, and the pilot device, and control circuit affecting controller functions. Provide controllers that are horsepower rated to suit the motor controlled in accordance with the standards.
- C. Contacts shall open each unearthed connection to the motor.
- D. Overload Relays: ambient-compensated type with inverse-time-current characteristic and fitted with differential element for single phasing protection. Provide with heaters or sensors in each phase matched to nameplate full-load current of the specific motor to which connected with appropriate adjustment for duty cycle.
- E. Under Voltage Protection: provide on all three phase motors, and where indicated otherwise.
- F. Earth fault protection provide on motor circuits of sizes 10 hp and larger with adjustable current and time setting.
- G. Motor Protection: in general where no other reference is indicated use the "IEEE Guide Protection", (ANSI/IEEE C.37.96). Provide thermistors and relays embedded in motor windings for motors 50 HP and higher rating and where shown on drawings.
- H. Enclosures: for individually mounted motor controllers and control devices, comply with Section "Electrical Cabinets, Boxes and Fittings" and with IEC 60439, IEC 60947-1. Provide enclosures suitable for the environmental conditions at the controller location. As a minimum, provide IP42 to IEC 60529 to an approved manufacturer's standard colour and finish, except as otherwise required.
- I. Interlock is to be provided between disconnect or circuit breaker such that the cover or door to any controller unit cannot be opened unless the switch or circuit breaker are placed in the off position, before accessing the internal components of a controller or combination starter.
- J. Padlocks: provide operating handle of disconnect devices with padlockable means suitable for at least

2 padlocks.

2.3 MANUAL MOTOR CONTROLLERS

- A. Fractional HP Manual Controllers: where indicated, provide single-phase two-pole manual starters for fractional HP motors as shown on drawings. Manually operated controller are to be equipped with quick-make, quick-break toggle mechanisms; and with one-piece thermal bi-metal type overload element per phase. Controller to become inoperative when thermal unit is removed. Provide controllers with double break silver alloy contacts, and with green pilot lights, for indicating "on" position, controller should be capable of being padlocked in OFF position.

2.4 MAGNETIC MOTOR CONTROLLERS

- A. Description: provide full-voltage, nonreversing, across-the-line, magnetic controller for ratings up to 10HP
, except where otherwise indicated (Refer to Drawings and Schedules).
Provide single-pole or 3-pole manually resettable overload element for single phase or three-phase motors, respectively. Contactors are to be suitably selected in accordance with IEC for type of duty cycles.

- B. Control Circuit: 120 V. Provide control power transformer integral with controller where no other supply of 120 V control power to controller is indicated. Provide control power transformer with adequate capacity to operate connected pilot lights, indicating and control devices, plus 100 percent spare capacity. Provide Local/automatic/off selector switch where indicated and start-stop push buttons for local control.
- C. Combination Controller: switch type; non fused; quick-make, quick-break mechanism; factory assembled with controller and arranged to disconnect it.
- D. Combination Controller: motor circuit protector or circuit-breaker type, factory assembled with the controller, calibrated to coordinate with the actual locked-rotor current of the connected motor and the controller overload relays. Provide motor-circuit protectors with field-adjustable trip elements as specified in Division 16 Section "LV Circuit Breakers".

2.5 REDUCED VOLTAGE MOTOR CONTROLLERS

- A. Solid-State Reduced Voltage Controllers: provide where indicated, solid-state reduced voltage controllers for use with 3-phase squirrel cage induction motors, of types, sizes, ratings and electrical characteristics indicated; construct with silicon-controlled rectifiers (SCR's) complete with surge and transient protection to prevent malfunction for controlling motor voltages during acceleration. Provide LEDs to indicate motors and control status and malfunctions. Equip controllers with circuit breakers, and with closed-loop feedback system to maintain motor acceleration at constant rate.
- B. Wye-Delta Controllers: provide automatic wye-delta magnetic type controllers for motors over 10 HP up to 50 HP, of sizes, ratings and electrical characteristics indicated. Provide controllers of the closed-circuit transition type, including three 3-pole contactors as required, resistances, adjustable pneumatic timer, and 3-pole overload protection relay in the winding circuit. Equip with START-STOP push button for local control.
- C. Auto-Transformer Reduced Voltage Controllers: provide auto-transformer type reduced voltage controllers, for motors over 50HP of sizes, ratings and electrical characteristics indicated, using type with closed-circuit transition feature. Construct controllers with 3-pole contactors, 3-phase starting auto-transformer, adjustable pneumatic timer, and 3-pole block type overload relay. Construct auto-transformer with voltage taps at 50 percent, 65 percent and 80 percent of full line voltage, and with thermal overload protection device on each phase to protect against overheating. Duty cycle of starters for motors up to 200 HP is to be 15 second operation out of each 4 minutes for one hour, repeated after two hours. For motors over 200 HP, starter duty cycle is to be 3 periods of 30 second on, 30 seconds off, repeated after 1 hour.
- D. Combination Controller: provide moulded case circuit breaker as disconnecting and over-current protection in common enclosure with controller.

2.6 VARIABLE SPEED DRIVES (VSDs)

- A. General requirements: The VSD shall be of the modern design, yet user friendly and be simple to install commission and maintain. The VSD shall be able to start and control the speed of a standard squirrel cage induction AC motor. The VSDs shall be CE marked. The VSDs have to be built to comply with the IEC standards.

- B. The materials used in the VSD as a complete unit shall be recyclable, non-toxic and flame retardant.
- C. The VSD shall have a bypass arrangement for the power supply for conditions of maintenance and repair, with contactors to ensure that "back-feed" is prevented.
- D. The VSD shall be a digitally controlled drive, using, at least, the pulse width modulation (PWM) with flux vector control, a direct torque control (DTC), or equivalent. It shall have IGBT's in the inverter section of the throughout the power range, and it shall have the following minimum specifications.

1. Operating conditions:

Rated Input Voltage: 380V - 400V, three-phase + 10 percent or + 10 percent - 10 percent, + 5 percent.

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|------------------------------------|---|---------------------------------|
| 2. Rated Input Frequency | : | 48-63Hz. |
| 3. Fundamental Power Factor | : | 0.97 or better at nominal load. |
| 4. Efficiency | : | >98 percent at nominal load. |
| 5. Output Voltage | : | 0- UN, 3 phase. |
| 6. Output Frequency Range | : | 0 to 300 Hz, adjustable. |
| 7. Output Frequency Resolution | : | 0.01 Hz. |
| 8. Accel / Decel Time | : | 0 - 1800 s, adjustable. |
| 9. Overload ability (by load type) | : | |

Constant Torque: 150 percent of nominal current for 1 min in every 5 mins. Variable Torque (pump & fan): No overload ability required.

10. Ambient Temperature: 40 deg. C (104 deg. F), for higher temperatures see below.
11. Installation Altitude: 1000 m .
12. Max. Relative Humidity: 90 percent, non-condensing. In presence of corrosive gases, the max. Relative humidity is 60 percent.
13. Main Protections: Over current, short circuit, input/output phase loss, motor overload and under load, over/under-voltage, over speed, over temperature, motor stall, other internal fault.

E. The VSD shall be able to give a 100 percent output current continuously in the above-specified conditions.

In order to ensure that the drive can provide the required output current in the specified ambient conditions, the manufacturer shall inform of the required de rating. The de rating factor shall be specified so that neither the lifetime of the VSD nor the unit's performance, overload ability included, nor the reliability of the VSD shall suffer.

F. Storage conditions (in the protective package): Ambient Temperature: - 40 to + 60 deg. C (40 to 158 deg.

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G. VSD Accuracy: The VSD shall have a minimum speed control accuracy of ± 10 percent of the nominal slip of the motor, without a pulse encoder feedback. In practice, this means e.g. for a 4 pole, 50 Hz motor with a 45 rpm slip speed, an accuracy of ± 0.3 percent of the motor nominal speed. The VSD shall be capable of a dynamic accuracy of at least 0.4 percent sec. without additional options. If this accuracy is not achieved without a speed feedback, the manufacturer shall specify the accuracy that can be reached and if required, a pulse encoder with adequate control devices shall be included in the motor unit at the VSD supplier's expense. The dynamic accuracy means the drive's capability to response fast in a dynamic situation, for example, if the load changes. It is measured by the change of speed and time, i.e. how long it takes to recover to the reference speed.

H. Starting torque and torque step rise time:

- Constant torque applications: The starting torque of the motor unit without a pulse encoder feedback shall be at least 150 percent of the rated motor unit torque.
- Variable torque applications: The starting torque of the motor unit without a pulse encoder feedback shall be at least 100 percent of the rated motor unit torque.

I. Enclosure and mounting: Enclosures shall be provided by the VSD manufacturer. VSD shall be equipped with fuses and a main circuit switch must be available . The switch shall be equipped with a door- interlocked handle, padlock able in the open position. Input fuses shall be of semiconductor type, and their characteristics coordinated with the drive's electronic protection circuits so that they do not blow from normal output faults such as an over current fault. The control panel of the VSD shall be accessible for programming and controls with the main door closed. The whole assembly shall be implemented with a strict consideration of the EMC compatibility and regulations as described further in the Specification.

J. Panel Design Specs:

1. Standards: IEC 60439-1, EN 60439 & VDE 660 Part 500.
 2. Protection Class: 1P 55.
 3. Cabinet access: From front.
 4. Cable entry and exit: Bottom entry as standard. Both bottom and top entry have to be possible.
 5. Colour: Grey RAL 7032 with White RAL 9003 inside the panel/s.
- K. User interface: The user interface shall be similar throughout the power range to avoid confusion amongst the users and need for training in several different units.
- L. Inputs and outputs: The following standard inputs and outputs at least shall be provided, to be used in interface with the control system:
1. Analog Inputs: 1 x Programmable differential voltage input 0(2) - 10V.
2 x Programmable differential current input 0(4) - 20mA.
 2. Analog Outputs: 2 x Programmable current outputs 0(4) - 20mA.
 3. Digital Inputs: 6 x Programmable Digital Inputs, opt isolated, common or Separate ground.
 4. Relay Outputs: 3 x Programmable Digital outputs with a changeover dry Contact.
All the control terminals shall be clearly marked.
- M. Serial communications: The VSD shall as standard have a provision for communication with PC software tools. In addition, the following serial communication protocols at least shall be available as option: Modbus, Modbus+, Interbus-S, Profibus DP, LON Bus and DeviceNet. It shall be possible to add the serial communication later.
- M. VSD keypad: The VSD shall have a detachable keypad with a backlit 4 line, 20 character

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alphanumeric operating display for programming and controlling purposes. The displayed messages shall be in user friendly, descriptive text. Coded messages are not acceptable. Parameter setting shall be possible by

using the keypad. Parameter setting shall be easily accessible and user friendly with actual text messages. Password protection shall be provided to avoid unauthorized tampering with the set parameters. It shall be possible to read and write the set parameters with the help of the control pad, enabling thus copying of parameters between the VSDs of a similar application, to save time during the commissioning and to avoid mistakes. The VSD shall have a local lockout to prevent accidental transfer from remote to local.

Direct keypad entry shall be provided to observe the following actual parameters. Any 3 of the following parameters or actual values shall be selected to be always displayed:

1. Input Voltage.
2. Input Frequency.
3. Output Voltage.
4. Output Frequency.
5. DC Bus Voltage.
6. Output Power.
7. Output Torque.
8. Output Current.
9. Motor Speed.
10. Process Speed.

The following parameters shall always be displayed during normal operation:

1. Speed Reference.
2. Run/Stop/Fault.
3. Remote/Local.

O. The VSD shall have self-diagnostic properties to display faults and warnings as they occur and be able to store at least 15 previous faults into the fault memory. The fault memory shall be accessible by PC maintenance tools. Necessary back-up battery pack with charging circuit shall be provided to ensure all data retention in the event of a power failure of 8 hours.

P. The following drive control functions at least shall be available from the keypad:

1. Run.
2. Stop.
3. Local / Remote selection.
4. Forward/Reverse (if function enabled).

5. Accelerate
(manual/mode).
6. Decelerate
(manual/mode).
7. Parameter
setting.
8. Scrolling and Viewing through
actual values.

Q. Application programming: The VSD shall be designed for both simple and the most complicated applications, yet it shall be user friendly. The VSD shall have built-in application macros, to allow selection of the range of preprogrammed control configurations and further, the VSD shall enable storing of two customer modified macros at least, to suit the specific application. It shall be possible to reset the parameter settings back to the original macro settings through the keypad. The parameter readouts shall be in text format and not coded. The VSD Supplier shall have a Windows based PC software available for monitoring and controlling the VSDs, and the software shall be offered as an option. The software shall be supplied with the necessary hardware and a provision for connecting a PC with the VSD. It shall be possible to set and modify parameters, control the drive, read actual values and make trend analysis using the software.

R. Software features:

1. Power loss ride-through: The drive shall have a power loss ride-through capability. This means that the drive controls should stay alive during a power loss by means of the energy stored in the load. The ride through time shall be the longer the higher the kinetic energy of the load is. The motor shall be magnetized as long as there is kinetic energy in the system.
2. Flying start: The drive shall have a built-in Flying Start feature. This feature will allow a motor unit which is still rotating, to be restarted without first stopping it. The VSD shall restart the motor from the rotating speed and then reaccelerate to the speed indicated by the speed reference signal. The Flying Start feature shall be available in both directions, to be able to start the drive in the required direction regardless of the rotation direction of the motor.
3. Flux Optimization: The VSD shall have a built-in automatic flux optimization function. The flux optimization function minimizes the sum of the magnetizing current and the load current so that the drive can still follow the given reference. This feature reduces energy consumption and motor noise when driving at less than the nominal load.
4. Flux braking: There shall be a possibility for Flux Braking, where VSD increases the motor magnetization to dissipate the extra energy in case of need for small braking power. It shall be possible to use the braking to decelerate the motor from one speed to another not only for stopping the motor.

5. Critical speed jump-over: The VSD shall have programmable skip speeds to jump over critical resonance speeds. If the speed reference is in the critical speed area, it is ignored and the latest speed reference is maintained. 3 programmable critical speeds at least shall be available.
6. Current/speed limiting: In case the acceleration or deceleration ramps are too fast for the drive capacity, the drive shall be able to automatically reduce the ramp to prevent tripping. Also, in case of transient overloads the drive shall automatically reduce speed to prevent an over current trip, if the drive capacity is not sufficient to handle the load.
7. PID-controller: The drive shall have a built-in PID-controller for control of the customer process.
8. Restart in the event of a fault trip due to over voltage, over current or loss of analog signal, the VSD shall be programmable to attempt an automatic restart. For safety reasons, the maximum number of attempts shall be five (selectable) within a short time. If the fault does not clear after the attempts, the drive shall lock out.

S. Environmental effects:

1. Harmonic Distortion: The VSD shall have built-in ac or dc chokes to minimize the total harmonic distortion (THD). The THD of the unit for current has to be less than 50 percent in a supply network with a short circuit ratio (Rsc) of 300 (i.e. the ratio of the supply network's short circuit current to the unit's nominal current). However, the VSD manufacturer shall submit to the Contractor the VSD harmonic spectrum for the Project specific supply network. The spectrum shall be used in the design of appropriate harmonic filters, if required by the Customer. The single harmonics shall be presented up to 25th harmonic and the THD has to be calculated taking into consideration harmonics up to 40th harmonic.
2. EMC Regulations and Compatibility/C-Tick: The supplied VSDs shall carry the CE mark (or C-Tick in Australia) indicating that they comply with the essential requirements of the relevant EU directives (or C-Tick requirements in Australia). The VSDs shall meet the requirements set in EN 61800-3 for Industrial Low-Voltage Networks. If separate EMC filters are required, they shall be of built-in type. A detailed description and other directions to maintain the EMC Compatibility during the installation of the VSD and associated field cables and connections, shall be given by the Supplier in conformance with the EMC Directives or C-Tick. The Contractor shall follow the directions during installation, in order to achieve attenuation of the RFI.
3. Audible Noise: The full load audible noise of the frequency converter as measured at a distance of 1000mm, shall not exceed 70 dB(A) in 200 kW applications and below. Above 200 kW, the full load audible noise shall not exceed 78 dB(A). If the frequency converter is installed in a cabinet and requires a separate cooling fan, these limits also include the noise of the additional cooling fan. This requirement is made to keep the electrical room quiet so that it is not necessary to use hearing protection. The audible noise of the motor should also be minimized. For that purpose the switching frequency of the frequency converter shall be at least 2 kHz throughout the power range.
4. Efficiency: The full load efficiency of the VSD shall be at least 98 percent including all the additional equipment, which is needed to meet the Specification.

2.7 AUXILIARY CONTROL DEVICES

- A. General: factory installed in controller enclosure except as otherwise indicated. Where separately mounted, provide suitably protected enclosure to standards applicable, except as otherwise indicated.
- B. Pushbutton Stations, Pilot Lights, and Selector Switches: heavy-duty type.
- C. Stop and Lockout Pushbutton Station: momentary-break pushbutton station with a factory-applied hasp arranged so a padlock can be used to lock the pushbutton in the depressed position with the control circuit open.
- D. Control Relays: auxiliary and adjustable time-delay relays.
- E. Ammeters, Voltmeters, and Frequency Meters: panel type, 75 mm minimum size with 90-deg or 120-deg scale and plus or minus 2-percent accuracy. Where indicated, provide transfer device with an off position.
- F. Current Sensors: rated to suit application.
- G. Phase-Failure and Under voltage Relays: solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable under voltage setting.
- H. Current-Sensing, Phase-Failure Relay: solid-state sensing circuit with isolated contacts for hard-wired connection. Arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage. Provide adjustable response delay.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Manual Controllers: use for single-phase motors except as indicated.
- B. Pushbutton Stations: except as otherwise indicated, provide momentary-contact start-stop units. Provide in covers of magnetic controllers for manually started motors where indicated, and connect start contact in parallel with sealing auxiliary contact for low-voltage protection.
- C. Manual-Off-Automatic Selector Switches: except as otherwise indicated, install in covers of magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment. Make control connections so that only the manual and automatic control devices that have no safety functions will be bypassed when the switch is in the manual position. Connect motor-control circuit in both hand and automatic positions for safety type control devices such as low- and high- pressure cut-outs, high- temperature cut-outs, and motor-overload and over current protectors. Make control-circuit connections to a manual-off-automatic switch or to more than one automatic control device in accordance with a wiring diagram that is Manufacturer and Engineer approved.

3.2 INSTALLATION

- A. General: install independently mounted motor control devices in accordance with manufacturer's written instructions.
- B. Manufacturer's Field Services: arrange and pay for the services of a factory-authorized service representative to inspect the field assembly and connection of components, and supervise the pre testing and adjustment of solid-state controllers.
- C. Location: locate controllers as indicated and within sight of motors controlled.
- D. Mounting: for control equipment at walls, bolt units to wall or mount on light-weight structural steel channels bolted to the wall. For controllers not at walls, provide free standing racks fabricated of structural steel members and light-weight slotted structural steel channels. Use feet consisting of 1,0 mm (3/8-inch) thick steel plates, 150 mm (6- inches) square, bolted to the floor. Use feet for welded attachment of (40 mm (1-1/2-inch)by 40 mm (1-1/2-inch) by 6 mm (1/4-inch) vertical angle posts not over three feet on centers. Connect the posts with horizontal lightweight slotted steel channels and bolt the control equipment to the channels.
- E. Motor-Controller Over current Devices: conform to requirements of Division 16 Sections "LV Circuit Breakers".

3.3 IDENTIFICATION

- A. Identify motor control components and control wiring in accordance with Division 16 Section "Electrical Identification."

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between motor control devices and control/indicating devices as specified in Division 16

Sections "LV Wires and Cables" for hard-wired connections.

B. Install wiring in enclosures neatly bundled, trained, and supported.

3.5 CONNECTIONS

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

3.6 FIELD QUALITY CONTROL

- A. Independent Testing Organization: arrange and pay for the services of an independent electrical testing organization to perform tests and observations on motor control devices.
- B. Reports: prepare written reports certified by testing organization of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made.
- C. Labeling: on satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.
- D. Schedule visual and mechanical inspections and electrical tests with at least one week's advance notification.
- E. Pretesting: on completing installation of the system, perform the following preparations for tests:
1. Make insulation resistance tests of conducting parts of motor control components; and of connecting supply, feeder, and control circuits. For devices containing solid-state components, use test equipment and methods recommended by the manufacturer.
 2. Make continuity tests of circuits.
 3. Provide set of Contract Documents to test personnel. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
 4. Provide manufacturer's instructions for installation and testing of motor control devices to test personnel.
- F. Visual and Mechanical Inspection: include the following inspections and related work.
1. Motor-Control Device Ratings and Settings: verify that ratings and settings as installed are appropriate for final loads and final system arrangement and parameters. Recommend final protective-device ratings and settings where differences are found. Use accepted revised ratings or settings to make the final system adjustments. Prepare and submit the load current and overload relay or relay heater list.
 2. Inspect for defects and physical damage, labelling, and nameplate compliance with current project drawings.
 3. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instructions.
 4. Check tightness of electrical connections of devices with calibrated torque wrench. Use manufacturer's recommended torque values.
 5. Clean devices using manufacturer's approved methods and materials.
 6. Verify proper fuse types and ratings in fusible devices.
- G. Electrical Tests: perform the following in accordance with manufacturer's instructions:
1. Insulation resistance test of motor control devices conducting parts to the extent permitted by the manufacturer's instructions. Insulation resistance less than 100 megohms is not acceptable.
 2. Use primary current injection to check performance characteristics of motor-circuit protectors and for overload relays of controllers for motors 15 horsepower and larger. Trip characteristics not within manufacturer's published time-current tolerances are not acceptable.
 3. Make adjustments for final settings of adjustable-trip devices.

4. Test auxiliary protective features such as loss of phase, phase unbalance and under voltage to verify operation.
 5. Check for improper voltages at terminals in controllers that have external control wiring when controller disconnect is opened. Any voltage over 30 V is unacceptable.
- H. Correct deficiencies and retest motor control devices. Verify by the system tests that specified requirements are met.

3.7 CLEANING

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

3.8 DEMONSTRATION

- A. Training: arrange and pay for the services of a factory-authorized service representative to demonstrate solid-state and variable-speed controllers and train Owner's maintenance personnel.

- B. Conduct a minimum of 4 hours of training in operation and maintenance as specified under "Instructions to Owner's Employees" in the general and special conditions of contract Section "Project Closeout." Include training relating to equipment operation and maintenance procedures.
- C. Schedule training with at least seven days' advance notification.

END OF SECTION
16481

**SECTION
16482**

**MOTOR-CONTROL
CENTERS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this Section:
 - 1. "Basic Electrical Requirements."
 - 2. "Motor Controllers".

1.2 SUMMARY

- A. This section includes motor-control centers (MCC's) and motor control panels (MCP's) for use on a.c. circuits rated 600 V or less, as shown on drawings and schedules.
- B. Related Sections: the following Division 16 Sections contain requirements that relate to this Section:
 - 1. "LV Circuit Breakers" for circuit breakers, and other similar devices used in MCC's/MCP's.
 - 2. "Motor Controllers" for motor-control devices installed in MCC's/MCP's.
 - 3. "Electrical Identification" for identification labels and warning signs for MCC's/MCP's and their components.
 - 4. "LV Wires and Cables", for insulated cables used in switchgear.
- C. Refer to applicable sections in Division 15 for requirements in connection with system control and operation.
- D. Refer to Division 15 section "Building Management System" for connection to BMS.

1.3 SUBMITTALS

- A. General: submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Product data for each product and component specified or required for the installation.
- C. Shop drawings for each MCC/MCP including dimensioned plans and elevations and component lists.
Show ratings, including short-time and short-circuit ratings, and horizontal and vertical bus ampacities.

- D. Schedule of features, characteristics, ratings, and factory coordinated protective settings of individual MCC/MCP units.
- E. Wiring Diagrams: interconnecting wiring diagrams pertinent to the class and type specified for the MCC/MCP. Schematic diagram of the whole installation, elementary diagrams of each controller unit clearly indicating components and terminal markings.
- F. Shop drawing of spare fuse cabinet showing material, dimensions, and features including storage provisions for fuse cartons.
- G. Qualification data for field-testing organization certificates, signed by the Contractor, certifying that the organization complies with the requirements specified in Quality Assurance below. Include list of completed projects with project names, addresses, names of Engineers and Owners, plus other information specified.
- H. Certified reports of field tests and observations specified in the article "Field Quality Control" in this Section.
- I. Maintenance data for MCC's/MCP's, for inclusion in "Operating and Maintenance Manuals" specified in

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Division 1 and in Division 16, Section "Basic Electrical Requirements."

1.4 QUALITY ASSURANCE

- A. Compliance with IEC or BS: comply with the requirements of the following standards, as applicable: IEC 60269.1, BS 88 Cartridge fuses
- | | |
|--|---|
| IEC 60255, IEC 50050, BS 142 | Electrical Protective Relays |
| BS 159 | Busbar and Busbar Connections |
| IEC 60185, BS 3938 | Current Transformers |
| IEC 60337-2, BS 4794 PT2 | Control Devices |
| IEC 50051 and IEC 512, BS 89 | Direct acting Indicating analogue Electrical measuring Instruments. |
| IEC 50521, BS 5685 | Electric Meters |
| IEC 60144, BS 5420 | Degree of protection of enclosures |
| IEC 60947-184, BS 5424 PTI | Contactors |
| IEC 60947 | Low Voltage Switch gear & Control gear |
| IEC 60439, BS 5486 PTI | LV Switchgear and Control |
| Gear Assemblies. IEC 60292-1,1A, 1B, BS 4941 PTI | Motor |
| starters D.O.L. | |
| IEC 60292-2, BS 4941 PT2 | Motor Starter, Reduced Voltage Star /Delta |
| IEC 60292-4, BS 4941 PT4 | Motor Starter Reduced Voltage Auto Transformer |
| NEMA ICS 2 assemblies | Industrial control devices, controllers and |
- B. Field-Testing Organization Qualifications: to qualify for acceptance, the testing organization must demonstrate, that it has the experience and capability to conduct satisfactorily the testing indicated.
- C. Product Selection for Restricted Space: ensure that MCC/MCP spaces are sufficient for type and size of MCC's, including clearances from adjacent surfaces, for feeder management and installations entering or leaving the MCC's/MCP's and for maintenance.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.
- B. Store so condensation will not occur on or in MCC's/MCP's. Provide temporary heaters as required to prevent condensation. Store MCC's/MCP's in clean dry spaces. Protect from weather, dirt, fumes, water, construction debris and physical damage.
- C. Handle MCC's/MCP's in accordance with manufacturer's rigging and moving instructions.

1.6 SPARE PARTS

- A. Spare Fuses: furnish six spares of each type and rating of fuse and fusible devices required.
Include spares for:
1. Control power fuses.
- B. Spare Indicating Lights: furnish 10 of each type required. C. Touch-Up Paint: furnish 3 half-pint containers.

- D. Push buttons and selector switches: furnish 4 Nos of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 MOTOR-CONTROL CENTERS (MCC's)

- A. Type: totally enclosed freestanding sectional type, with sections joined to form one assembly. Sections to be designed to allow other sections to be easily added or removed.
- B. Construction: 2 mm thick sheet steel, adequately reinforced and braced for maximum rigidity, sand blasted, rust inhibited after fabrication and sprayed with one coat primer and two coats enamel internally and externally.
- C. Enclosure: to IEC 60439 and IEC60947-1, protection IP51 to IEC 60529 except as otherwise indicated.
1. Use of draw-out design for combination starter units. Reduced voltage controllers for motors above 150 HP may be of the fixed mounted type.
- D. Voltage Rating: 1000V rated insulation voltage and 600V rated operational voltage.
- E. Wiring Classification: class II, Type B, as defined in NEMA ICS 2 or equal standard (unit wiring diagrams including interconnection and interlocking to be provided by MCC supplier, and each starter unit to be completely factory inter wired up to a terminal back to be provided per unit, including inter wiring between units and interlocking provisions to remote devices).
- F. Compartments: modular, with individual doors with concealed hinges and quick-captive screw fasteners.
For combination starter units provide interlocks so that disconnect means must be in the off position before door can be opened, and so door cannot be closed with the disconnect means in the on position, except by consciously operating a permissive release device. Provide handles with off position down and which can be locked in the off position.
- G. Interchangeability: construct compartments so that it is possible to remove units without opening adjacent doors, disconnecting adjacent compartments, or disturbing the operation of other units in the control center. Units requiring the same size compartment shall be interchangeable, and compartments shall be constructed to permit ready rearrangement of units such as replacing 3 single units with a unit requiring 3 spaces without cutting or welding.
- H. Wiring Spaces: provide each vertical section of structure with horizontal and vertical wiring spaces for wiring to each unit compartment in each section. Provide supports to hold wiring rigidly in place.
- I. Short-Circuit Current Rating for Each Section: equal to or greater than indicated available fault current of the system in rms symmetrical amperes at the motor-control center location for one second minimum, at rated voltage and frequency.

- J. Schematic Wiring Diagrams: to be firmly fixed under glassene within each motor control unit, showing each component, terminal markings and component symbols and labels.

2.3 MOTOR CONTROL PANELS (MCP'S)

- A. Type: wall mounted or unit mounted, lockable type, IP42 for indoor installations.
- B. Construction: minimum 1.5 mm thick hot-dip galvanized steel sheet, finished with one coat etch primer and one coat stove enamel internally and externally.
- C. Panels Installed Outdoors and in Wet Areas: to have weatherproof totally sealed water and dustproof IP55 enclosures.
- D. Voltage Rating: 1000V rated insulation voltage and 600V rated operational voltage.
- E. Components: panels are to contain necessary breakers, starters, busbars, push buttons switches, selector switches, relays, indicating lights, interconnecting and interlock wiring and all devices and accessories required for automatic or manual operation of equipment as specified under equipment concerned.

- F. Labels: starters, switches, electrical devices and accessories to be clearly labelled in English as to function and number. Labels to be permanently fixed under each component.
- G. Schematic and wiring diagrams to be mounted in permanent approved manner on inside of panel door.
Diagrams are to show each component cross referenced with component labels.

2.4 BUSES

- A. Material: 98% pure electrolytic copper, with electro-silver plated contact surfaces, full length, one piece, sized based on a total maximum operating temperature of 90 C at full continuous rating (40 C temperature rise above 50 C ambient).
- B. Ampacity Ratings of Main Buses: as main incoming device ; circuit breaker or disconnect switch, or as indicated on drawings.
- C. Neutral Buses: Full size.
- D. Equipment Earthing Bus: non-insulated, horizontal copper bus 50 mm (2-inches) by 6mm (1/4- inch), minimum, and in accordance with the standards.
- E. Busbar Arrangement: extend main phase, neutral and ground buses with same capacity the entire length of the MCC/MCP, with provision for future extension at both ends by means of bolt holes and captive bus splice sections or approved equivalent.

2.5 FUNCTIONAL FEATURES

- A. General: provide a modular arrangement of motor controllers, control devices, over current protective devices, transformers, instruments, indicating panels, blank panels, and other items mounted in the compartments of the motor-control center as indicated.
- B. Motor Controller Units: provide combination controller units as specified in Division 16 Section "Motor Controllers"; of types and with features, ratings, and circuit assignments indicated. Provide units that automatically line up and connect with vertical section buses while being racked into their normal energized positions. Units shall have short-circuit current ratings equal to or greater than the short-circuit current rating of the MCC/MCP section.
- C. Over current Protective Devices: provide types of devices with features, ratings, and circuit assignments indicated. Individual feeder tap units acceptable through 250 ampere rating only, shall be installed on draw out mountings with connectors that automatically line up and connect with vertical section buses while being racked into their normal energized positions.
- D. Phase Failure and Phase Sequence Protection: is to be provided on the main circuit breaker/switch of the MCC's/MCP's with individual trip indication form each function. Necessary shunt trip devices are to be provided.
- E. Spaces and Blank Units: compartments fully bussed and equipped with guide rails or equivalent, ready for insertion of draw out units.
- F. Spare Units: fully equipped with breakers/starters, with type, sizes, and ratings as indicated, and installed in compartments indicated "spare."

- G. Connection to BMS: coordinate with the BMS supplier and provide all necessary interface devices, instruments, transducers, dry contacts, etc. in the MCC's/MCP's for connection of all required points to the BMS as specified or indicated in the BMS schedules.

2.6 IDENTIFICATION PRODUCTS

- A. Provide identifying devices as specified in division 16 section "Electrical identification"

2.7 FINISHES

- A. Manufacturer's standard finish suitable for the environment in which installed.
Colour to be approved by the Engineer

2.8 CONCRETE BASES

- A. Concrete and Reinforcement: provide in accordance with Specification
- B. Shop Drawings and Details: provide exact dimensions and all provision necessary for framing, cabling provisions and submit for approval by the

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: install MCC's/ MCP's in accordance with the manufacturer's written installation instructions and regulations/codes applicable.
- B. Anchor each motor-control center assembly to steel-channel sills arranged and sized in accordance with manufacturer's recommendations. Attach by tack welding or bolting. Level and grout sills flush with motor-control center mounting surface.

3.2 CONCRETE BASES

- A. General: where a membrane-waterproofed floor or pressure slab is indicated under the MCC/MCP location, or elsewhere as indicated, provide a concrete foundation pad. Install 100 mm-high sills on the pad as specified above.
- B. Form concrete equipment bases having permanent steel frame, using approved standard steel channels, locate as indicated, and construct 100 mm (4 inches) larger in both directions than supported unit. Miter and weld corners and provide cross bracing. Anchor or key to floor slab.
- C. Install reinforcing bars tied to frame, and place anchor bolts and sleeves using manufacturer's installation template.
- D. Form concrete equipment bases using framing lumber with form release compounds. Locate as indicated and construct 100 mm (4 inches) larger in both directions than supported unit. Chamfer top edges and corners.
- E. Install reinforcing bars, and place anchor bolts and sleeves using manufacturer's installation template. F. Place concrete and allow to cure before installation of equipment.
- G. Clean exposed steel frames and apply 2 coats of rust-preventative metal primer and 2 coats of exterior, gloss, alkyd enamel in color selected by the Engineer.
- H. Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from MCC units and components.

3.3 IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Electrical Identification."

- B. Operating Instructions: frame printed operating instructions for MCCs, including control sequences, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of MCC's/MCP's.

3.4 CONNECTIONS

- A. Tighten MCC/MCP bus joint bolts and electrical connector and terminal bolts in accordance with manufacturer's installation instructions and torque-tightening values. Where manufacturer's torque values are not stated, use those specified in applicable standards.

3.5 FIELD QUALITY CONTROL

- A. General: comply with applicable requirements of the Engineer approved testing organization.
- B. Testing Organization: arrange and pay for the services of an independent electrical testing organization to perform quality control electrical testing and calibration, visual and mechanical inspections, and tests of MCC's/MCP's.
- C. Testing Preparation and Pretesting: perform the following preparations for tests:
1. Test insulation resistance of buses and portions of control wiring that disconnect from solid-state devices through normal disconnecting features. Insulation resistance less than 100 megohms is not acceptable.
 2. Make continuity tests of circuits.
 3. Provide set of Contract Documents to test organization. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
 4. Provide manufacturer's instructions for installation and testing of MCC/MCP to test organization.
 5. Inspect MCC's/MCP's for defects and physical damage, testing laboratory labels, circuit connections, and nameplate compliance with up-to-date system drawings.
 6. Perform operational test and exercise of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
 7. Check MCC/MCP anchorage, external clearances, and alignment and fit of components including internal elements.
 8. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
 9. Perform visual and mechanical inspection and related work for motor control and protective devices as specified in Division 16 Sections "LV Circuit Breakers" and "Motor Controllers."
 10. Device Ratings and Settings: verify ratings and settings of overload relays, motor circuit protectors, and any over current protective devices. Make final adjustments of devices in accordance with Division 16 Sections "LV Circuit Breakers" and "Motor Controllers "or other related Sections of the Specification and drawings.
- D. Quality Control Testing Program: assure MCC/MCP installation meets specified requirements, is operational within specified tolerances, and provides appropriate protection for systems and equipment.
1. Test and inspect MCC's/MCP's in accordance with manufacturer's recommendations and these specifications.
 2. Schedule tests and provide notification at least 1 week in advance of test commencement.
 3. Reports: prepare written reports of test results and observations. Report defective materials and workmanship. Include complete records of adjustments and corrective action taken.
 4. Labeling: On satisfactory completion of tests and related work, apply a label to tested components indicating results, person responsible, and date.
 5. Verify appropriate capacity, over current protection, and operating voltage of control power elements including control power transformers and control power wiring.
 6. Check phasing of supply source to the bus.
 7. Test motor-control devices as specified in Division 16 Section "Motor Controllers."
 8. Test over current protective devices as specified in Division 16 .

E. Retesting: correct deficiencies and retest. Verify by the retests that specified requirements are met.

3.6 CLEANING

A. Inspect interior and exterior of MCC's/MCP's. Remove paint splatters and other spots, dirt, and debris.
Touch up scratches and mars of finish to match original finish.

3.7 EARTHING

A. Provide equipment earthing of MCC's/MCP's as indicated and as specified in Section "Earthing". Tighten connections to comply with tightening torques specified by Manufacturer or in applicable standards to ensure permanent and effective earth.

3.8 DEMONSTRATION

A. Training: arrange and pay for the services of factory-authorized service representatives to demonstrate
MCC's/MCP's and train Owner's maintenance personnel.

- B. Training: conduct a minimum of 4 hours of training in operation and maintenance as specified under "Instructions to Owner Employees" in the general and special conditions of contract Section "Project Close- out." Include training relating to equipment operation and maintenance procedures.
- C. Schedule training with at least seven days' advance notification.

END OF SECTION
16482

**SECTION
16490**

**POWER FACTOR
CORRECTION**

PART 1 – GENERAL

1.1 GENERAL REQUIREMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions, and Division-1 Specification sections, apply to work of this section.
- B. The requirements specified in this section apply to all related sections in this Division. The requirements of all related sections, elsewhere in this division also apply to this section unless specified to the contrary.
- C. Basic Electrical Requirements, Section 16010, apply to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete, make ready and set to work for operation by the Owner, power factor capacitors correction in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Acceptable manufacturers: Firms regularly engaged in the manufacture of switchboards of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years as approved by Engineer.
- B. Standards Compliance: Comply with requirements of applicable local codes and 1EC, BS EN 60143, BS EN 61000 , D1N/VDE, NEC, UL, NEMA, ANSI, and IEEE Standards pertaining to centralized automatic power factor capacitor assemblies. Provide centralized automatic power factor capacitor assemblies and components conforming to one or more of the foregoing codes and standards.
- C. In case of conflict among the referenced standards and codes, the more stringent provision will govern.

1.4 SUBMITTALS

- A. Product data: Submit manufacturer's data for centralized automatic power factor capacitor assemblies including sizes, enclosures, electrical ratings , characteristics and wiring diagrams.
- B. Shop Drawings: Submit dimensional layout on architectural background drawings of centralized automatic power factor capacitor assemblies with related low tension, single-line diagram, and outline drawings.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 GENERAL

- A. Provide fully automatic capacitor assemblies for low tension applications as indicated on the plans and single line diagram. B. Assemblies shall be fabricated as extensions of the low tension Main distribution board when indicated.
- C. Each assembly (unit) shall provide 95% power factor correction with built in safeguards to prevent over capacitance.

2.3 RATINGS

- A. The voltage rating of the power factor correction equipment shall be 380 volts between phases.

- B. The total KVAR capacity of the assembly units shall be as indicated on drawings.
- C. The total KVAR shall be automatically switched in steps of 25/50 KVAR as indicated on the drawings.

2.4 CAPACITOR CELLS - DRY TYPE

- A. Individual capacitors shall be self-healing utilizing polypropylene as a dielectric with vacuum deposited conductors on the polypropylene as electrodes.
- B. Each three phase capacitor shall be furnished with an approved pressure sensitive interrupter. The interrupter shall disconnect all three phases at the same time to maintain a balanced circuit.
- C. Capacitors shall be contained in hermetically sealed metal cans to prevent atmospheric contaminants from shortening the useful life.
- D. Dielectric material shall be low loss, less than 0.5 watts per KVAR.
- E. Dry cells encapsulation medium shall be a thermoplastic material which allows out gassing engaging the pressure interrupter.
- F. Terminal bushings shall withstand 10 KV AC to ground and be rated 30 KV BII or greater.
- G. Nominal design life of individual capacitor cells shall be 20 years.
- H. Individual capacitor cells shall be covered by a five year warranty.
- I. All capacitor cells shall have threaded terminals for wire connection.
- J. To reduce line transients on system. No stage shall switch more than 120 KVAR and no capacitor cell shall exceed 25.0 KVAR.

2.5 CONTROLS

- A. All controls shall be mounted on enclosure door for easy inspection and service.
- B. A door interlock shall be provided to disconnect control power when enclosure door is opened.
- C. A personnel ground fault breaker shall be provided to disconnect control power upon accidental contact with control power and earth (ground).
- D. Reactive Power Controller/Power Factor Meter:
 - 1. Controller shall measure the reactive current on every passage of the voltage through zero.
 - 2. A LED display shall be provided to indicate the stages that are On.
 - 3. To prevent leading power factor, the controller shall be provided with a programmable target cosine selector.
 - 4. The time delay between switching of capacitors must be field programmable and have a range of 10 seconds to 10 minutes to reduce hunting and allow voltage decay as noted in par. 2.8.
 - 5. All output contacts shall be disabled within 15 milliseconds of main power interruption. The controller shall retain its programming after the restoration of supply voltage. The controller shall bring the capacitor bank back on line in a step, phased and normal sequence.
 - 6. Controller shall be able to select 1:1:1, 1:1:2 and 1:2:2 switching sequence of capacitor steps.

7. Controller shall be able to display power factor with indication for an inductive or capacitive power factor.
8. E. On-Off Switch
9. On/Off switch shall control power to all door mounted controls.
10. On/Off switch shall contain pilot light to indicate "On" mode.

E. Blown Fuse Lights

1. Three "Push-To-Test" blown fuse pilot lights, one per phase-door mounted, to indicate a blown fuse condition.
2. Each fused phase, of each 50 KVAR step, shall have its own blown fuse indicating light mounted in close proximity to the fuse for easy identification.

2.6 ENCLOSURE

- A. The enclosure shall be fabricated from 2.65 mm minimum thick, cold rolled steel. B. An internal grounding lug shall be provided.

- C. A baked enamel finish in matching switchgear grey color shall be used.
- D. Capacitor cells shall be accessible for visual inspection and replacement from the front of the cabinet. E. Removable lifting eyes shall be provided.
- F. The enclosure door shall have a three point latch with key locking handle.

2.7 GENERAL CONSTRUCTION

- A. All power wiring shall have a thermoplastic insulation rated for 105 degrees C at 500 volts.
- B. System wiring connections shall be made to copper bus bars braced for 65,000 amps or greater. C. Contactors shall be rated for switching of reactive current by the contactor manufacturer.
- D. The automatic power factor correction equipment shall be warranted by the manufacturer of the capacitor cells. E. Air core transient suppression coils shall be provided in series between the contactors and capacitor cells.
- F. All wiring connections shall be mechanically fixed with nut or screw.
- G. The automatic power factor correction shall be an expandable modular design.

2.8 DISCHARGE RESISTORS

- A. Capacitor "cells" shall be provided with discharge resistors to reduce residual voltage to less than 50 volts within one minute of de-energization, unless local codes govern otherwise.
- B. Resistors shall be chosen to insure a 20 years minimum life.

2.9 FUSES

- A. To provide for major fault protection, line fuses shall be provided on all three phases of each switched stage and fixed bank. B. Line fuses shall be current limiting, U.L., recognized Class T type. Minimum interrupting ratings shall be 200,000 amps for fuses of 30 amps and above.
- C. Fuses shall be designed for capacitor applications and shall be rated not less than 200% capacitor current rating.

2.10 PERFORMANCE FEATURES

- A. Capacitor shall be rated for continuous duty at 50 degree C ambient at 1,000 meters and below.
- B. Total Harmonic Distortion (THD) of 5% on either the voltage and current wave-forms shall not affect the life of capacitors, contactors or controllers.
- C. + 10% variation in line voltage shall not affect the life of the capacitor. D. All capacitors should be rated at 440 volt.

2.11 SYSTEM COMPATIBILITY

- A. Provide in each assembly, space and connection such that if in the future, chokes and filters will be required, the installation can be accomplished in the field with minimum down time.

2.12 TESTING

- A. All capacitor cells shall be traceable through construction and testing.
- B. The automatic capacitor bank shall be tested for proper operation prior to leaving the factory. The following checks, measurements, and operations must be confirmed and recorded for each stage.
- C. The certified record of these tests shall become part of the permanent documentation package that travels with the automatic capacitor bank.

1. Wire connections.
2. Torque connections.
3. Phase to phase, resistance checks.
4. Controller operation, manual operation.
5. Controller operation, automatic operation.

PART 3 – EXECUTION

3.1 INSPECTION

- A. Examine conditions under which centralized automatic power factor capacitor assemblies are to be installed. Notify the Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install centralized automatic power factor capacitor assemblies as indicated in accordance with manufacturer's written instruction, requirements of applicable standards, "Standard of Installation," or equal and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of centralized automatic power factor capacitor assemblies with other work.
- C. Mount the switchboard assembly on flush steel aligning channels elevated above floor level by a concrete pad. Provide aligning shims to achieve level installation where channels cannot be provided.
- D. Insure that centralized automatic power factor capacitor assemblies are shipped in sections which can be fitted through the structures and openings available.
- E. Bond together the centralized automatic power factor capacitor assemblies structure, sections and all conduits terminating at same with a copper earth (ground) cable and connect to the switchboard earth (ground) bus and to the earthing (grounding) grid as required.
- F. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors.
- G. Provide protective covering during construction
- H. Touch up marred or scratched surfaces to match original finish. I. Provide control fuses, with five spare fuses for each rating.
- J. Adjust operating mechanism for free mechanical movement.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of equipment and after circuitry has been energized, test equipment to demonstrate compliance with requirements. When possible, field-correct malfunctioning units, then retest to demonstrate compliance; otherwise remove and replace with new equipment and retest.

- B. Prior to energization of switchboards and centralized automatic power factor capacitor assemblies: Perform insulating resistance test on each pole, phase-to-phase and phase-to-earth for (1) minute. Minimum test voltage to be 1,000 volts D.C. with a minimum resistance of 100 megohms.
1. Check centralized automatic power factor capacitor assemblies for continuity and for short circuits.
 2. Notify Engineer for any abnormalities.
- C. After assemblies are energized, demonstrate functioning in accordance with manufacturers requirements.

3.4 MAINTENANCE

- A. All maintenance and inspection on the capacitor assembly shall be done with the system disconnect device in the open position. B. Maintenance and inspections should be limited to 15 minutes or less so not to affect utility billing.
- C. An annual inspection of the capacitor cell shall be done to identify failing capacitor cells (a bulged cover is the symptom to watch for).

END OF SECTION
16490

**SECTION
16515**

**INTERIOR
LIGHTING**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions of Contract, apply to work of this section.
- B. Division 16 "Basic Electrical Requirements" and other sections apply to work specified in this section.

1.2 SUMMARY

- A. This section includes complete interior lighting fixtures, emergency lighting units, control gear, mounting provisions, accessories and connection to circuit wiring and to corresponding lighting control equipment.
- B. Extent, location, and details of interior lighting fixture work are indicated on drawings and in schedules. C. Types of interior lighting fixtures in this section include the following:
 - 1. High-intensity-discharge (HID).
 - 2. Mercury-vapor.
 - 3. Metal-halide.
 - 4. High-pressure-sodium.
 - 5. Fluorescent.
 - 6. Incandescent.
 - 7. Emergency
- D. Design Layout: fixture layout has been determined from photometric data of specified fixtures to achieve desired level and uniformity of illumination. Reflected ceiling plans are to be checked to ensure exact positions of fixtures with respect to structural members, ducts, pipes, other installations and ceiling panels/tiles, where required. Certain fixtures are shown in provisional positions, pending preparation of final equipment layout drawings. Such fixtures are to be located in coordination with final equipment layout so that illumination is as intended by the design.
- E. Related Sections: the following Division 16 Sections contain requirements that relate to this Section:
 - 1. "Exterior Lighting Fixtures" for exterior security lighting, roadway and parking lot lighting.
 - 2. "Wiring devices" for modular dimmers, time switches, photoelectric relays, and contactors.

1.3 DEFINITIONS

- A. Emergency Lighting : a fixture connected to central battery system .
- B. Fixture: a complete lighting unit, exit sign, or emergency lighting. Fixtures include lamps and parts required to distribute the light, position and protect lamps, and connect lamps to the power supply.

C. Luminaire: fixture.

D. Rated Average Life: the time after which the average of a lamp type lumen output has reached down to 80% of its initial 100 hr value as specified, under normal conditions.

1.4 SUBMITTALS

A. Product Data: submit manufacturer's product data and installation instructions on each type interior building lighting fixture and component, any modification made necessary, catalog number, serial number, operating characteristics and photometric data.

1. Data on emergency lighting.
2. Product certifications signed by manufacturers of lighting fixtures certifying that their fixtures comply with specified requirements.

- B. Shop Drawings: submit layout drawings of interior lighting fixtures on reflected ceiling plans and their spatial relationship to each other and to other trades or systems such as structural members, ducts, pipes etc.. In addition, submit fixture shop drawings in booklet form with separate sheet for each fixture, assembled in "luminaire type" alphabetical or numerical order, with proposed fixture and accessories clearly indicated on each sheet. Submit details indicating compatibility with ceiling grid system.
- C. Wiring Diagrams: submit wiring diagrams for interior lighting fixtures showing connections to electrical power panels, switches, dimmers, controllers, and feeders. Differentiate between portions of wiring which are manufacturer-installed and portions which are field-installed.
- D. Samples: submit one complete operating unit for each type of light fixture specified, together with colour and texture samples where required.
- E. Maintenance Data: submit maintenance data and parts list for each interior lighting fixture and accessory; including "trouble-shooting" maintenance guide. Include that data, product data, and shop drawings in a maintenance manual; in accordance with general requirements of the general and special conditions of contract.

1.5 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: firms regularly engaged in manufacture of interior lighting fixtures of sizes, types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Fixture Design and Standards: the Specification and the Drawings are a guide to the selection of lighting characteristics and lighting fixtures, giving general features of construction, materials, method of installation and conditions of operation. Unless otherwise specified, fixtures are to be manufacturer's standard series, designed and manufactured for the purpose and application required, generally in accordance with the Schedule of Lighting Fixtures and complying with IEC 60598 and CISPR 15.
- C. Special Listing and Labeling: provide fixtures for use in damp or wet locations, underwater, and recessed in combustible construction specifically listed and labeled for such use. Provide fixtures for use in hazardous (classified) locations that are listed and labeled for the specific hazard.
- D. Installer's Qualifications: firms with at least 3 years of successful installation experience on projects with interior lighting fixture work similar to that required for this project.
- E. Electrical Code Compliance: comply with applicable local code requirements of the authority having jurisdiction or other code applicable to installation, and construction of interior building lighting fixtures approved for the project and as referenced in pertinent specification in this section.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver interior lighting fixtures in factory-fabricated containers or wrappings, which properly protect fixtures from damage.
- B. Store interior lighting fixtures in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, laid flat and blocked off ground.

- C. Handle interior lighting fixtures carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.

1.7 SEQUENCING AND SCHEDULING

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

1.8 SPARE PARTS

- A. Furnish Spare parts matching products installed, as described below, packaged with protective covering

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for storage, and identified with labels describing contents. Deliver spare parts to the Owner.

1. Complete Fixtures: a quantity equal to 2 percent of installed units of types shown on drawings for interior lighting with maximum quantity of 10 fixtures and min. quantity of one fixture of each type.
2. Lamps: 10 lamps for each 100 of each type and rating installed. Furnish at least 1 of each type.
3. Plastic Diffusers and Lenses: 1 for each 100 of each type and rating installed. Furnish at least 1 of each type.
4. Ballasts: 1 for each 100 of each type and rating installed. Furnish at least 1 of each type.
5. Globes and Guards: 1 for each 20 of each type and rating installed. Furnish at least 1 of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: subject to compliance with requirements, manufacturers are indicated on drawings against each luminaire selected in the design. Equal products may be considered subject to final decision and approval of the Engineer.
- B. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to approved manufacturer list.

2.2 LIGHTING FIXTURE CONSTRUCTION – GENERAL

- A. Generally: construction and wiring of fixtures are to comply with the Regulations and Standards.
Fixtures are to be fabricated, assembled and wired entirely at factory.
Manufacturer's name, factory inspection stamp and official quality label are to be fixed to each fixture supplied.
- B. Lighting Fixtures (Luminaires): to be manufacturer's standard, as given in Lighting Fixture Schedules shown on the Drawings, or equal.
- C. Sheet Steel Housings: to be not less than 0.6 mm thick, and thicker when required by the Specification or the Standards.
- D. Sheet Steel Reflectors: to be not less than 0.5 mm thick.
- E. Aluminium Reflectors: to be not less than 0.7 mm thick, unless otherwise approved.
- F. Fabrication: metalwork is to be mitered, welded and ground smooth without tool marks or burrs.
Flat metal parts are to be stiffened by forming grooves and edges during fabrication. Metal parts are to have finish free from irregularities.
- G. Rust-Proof Ferrous Base: ferrous metal parts are to be bonderized (treated with corrosion resistant phosphate solution) and given an approved rust-inhibiting prime coat before application of final finish.
- H. Finish for Non-Reflecting Metal Surfaces: approved baked enamel paint. Paint colour on fixture frames and trims is to be as specified or as selected by the Engineer.

- I. Finish for Light Reflecting Surfaces: white baked enamel paint having reflection factor not less than 85%.
Mirror reflectors, where specified, are to be highly polished, anodized aluminium with reflection factors not less than 97%.
- J. Mechanical Resistance of Finish: after finish has been applied on steel surfaces and cured, it is to withstand a 6 mm radius bend without showing signs of cracking, peeling or loosening from base metal.
- K. Resistance of Finish To Ultra-Violet: finish is to withstand 72 hours exposure to an ultra-violet RS lamp placed 100 mm from surface without discolouring, hardening or warping, and is to retain the same reflection factor after exposure.
- L. Heat Resistance: finishes, wires and components inside fixtures are to be certified materials to resist the temperatures or other conditions encountered in the fixtures.
- M. Wiring Inside Fixtures: to be not less than 1.5 mm², and insulated for 240 V application. Insulation is to have acceptable characteristics to resist maximum temperatures inside fixtures. Wiring is to be terminated on screw type fixed insulating terminal blocks.

- N. Hinges: fixtures with visible frames and hinged diffusers are to have concealed hinges and catches, and stainless steel retaining clips. Other alternative equally durable products may be submitted for approval.
- O. Suspension and Aligners: to be provided for pendant fixtures for axial, vertical and horizontal alignment.
Vertical adjustment is to be minimum 25 mm. Hangars to be 12 mm (1/2 inch) steel tubing of same finish as fixture with ceiling canopy or as approved or selected by Engineer.
- P. Recessed Fixtures: to be constructed to fit into suspended ceilings without distorting fixture or ceiling.
Plaster rings are to be provided for plaster or concrete ceilings.
- Q. Removal of Parts for maintenance is to be possible without removing fixture housing.
- R. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or water white, annealed crystal glass except as indicated.
1. Plastic: highly resistant to yellowing and other changes due to aging, exposure to heat and UV radiation.
 2. Lens Thickness: 4 mm (0.125 inches), minimum.
- S. Exit signs, if not fed from central battery system, are to be provided with integral automatic high/low trickle charger in a self-contained power pack. with sealed, maintenance-free, nickel cadmium battery and with special project warranty.

2.3 FLUORESCENT FIXTURES

- A. Lamp Holders generally: to IEC 400, heavy duty, moulded white plastic with non-corroding spring contacts.
- B. Lamp Holders for Industrial Fittings: spring loaded turret type, heavy duty, dust protected.
- C. Ballasts Generally: to IEC 82. Only single or two-lamp ballasts are to be used in any one fixture.
Two-lamp ballasts are to be lead-lag, series type. Equipment is to be enclosed in sheet steel casing with corrosion resistant finish.
- D. Ballast thermosetting compound is not to soften, liquify or support combustion under any operating condition or upon ballast failure, and is to fill ballast enclosure and dampen vibrations. Temperature rise, under normal operating conditions, is not to exceed 40 deg. C above maximum ambient temperature of 50 deg. C.
- E. Ballast Type: switch start, unless otherwise stated in fixture description or shown on the Drawings, power factor corrected to above 0.9, having manufacturer's lowest case temperature. Sound rating is not to exceed level given in the Standards.
- F. Ballast Rating: ballast is to be manufactured and certified for the specific lamp it controls and for operation from nominal power supply, with voltage and frequency equal to nominal voltage and frequency of distribution network.
- G. Capacitors: to IEC 566, having snap-type connectors and fastening, bolt type M8, for fixing to fixture.

- H. Starters, if required, are to comply with IEC 155, and are to be selected in conjunction with respective ballast and lamp.
- I. Electronic Ballast: for use on 26 mm and 38 mm diameter krypton or argon filled tubes are to be used in conjunction with electronic dimming controls or as specified. Dimming is to be possible down to 5% of normal output. Ballasts are to be with service life in excess of 10000 hours.

2.4 INCANDESCENT LAMP FIXTURES

- A. Incandescent Lamp Sockets: to IEC 61 and IEC 238, high grade porcelain; E27 (ES) screw sockets for lamps not exceeding 200 W and E40 (GES) screw sockets for lamps 300 W and over.

2.5 HIGH INTENSITY DISCHARGE LAMP FIXTURES

- A. Type: fixtures are to be complete units including integral ballasts (and ignitors for HPS lamps where indicated) and lamps of required number and type, and are to have lighting distribution characteristics equivalent to model and manufacturer indicated in the fixture description.
- B. Accessories: fixtures are to have mounting accessories, such as suspension rods or chains, rails or brackets, and protective glass covers with gaskets for protection against dust and humidity or type of corrosive atmosphere predominant in the location.
- C. Ballasts and Ignition Devices are to be power factor compensated to at least 0.9 lagging, and type specially selected for lamp type and size used. Lamp is to be able to start with at least +/-10% variation from nominal line voltage and continue in normal operation with dips attaining 20% for four seconds. Compensation is to ensure there is no great increase in operating current during starting and that gear losses do not exceed 10% of normal wattage. RF suppression circuit is to be provided.

2.6 EMERGENCY LIGHTING UNITS (if applicable)

- A. Conform to BS or equal international standards Provide self-contained units with the following features and additional characteristics as indicated.
- B. Battery: sealed, maintenance-free, lead-acid type with 3 hr autonomy (running time), 10 year nominal life minimum and special project warranty.
- C. Charger: minimum two-rate, fully-automatic, solid-state type, with sealed transfer relay.
- D. Operation: relay automatically turns lamp on when supply circuit voltage drops to 80-percent of nominal or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. Relay disconnects lamps and battery automatically and recharges and floats on trickle charge when normal voltage is restored.

2.7 LAMPS

- A. Rated voltage of incandescent and PL lamps are to be equal to nominal voltage of distribution network.
Lamps with different rated voltages are not acceptable.
- B. Incandescent Lamps for General Lighting Service (GLS): to have screw base type ES for lamps 200 W and below and type GES for lamps 300 W and above. Inside frosted (IF) lamps are to be used unless otherwise specified. Guaranteed rated life is to be above 800 hours and luminous output above the following:
 - 1. 950 lumens for 75 W lamps
 - 2. 1350 lumens for 100 W lamps
 - 3. 2200 lumens for 150 W lamps
 - 4. 3100 lumens for 300 W lamps.
- C. Reflector Lamps (R): for indoor and outdoor use, with silver reflector and prismatic lens. Light beam is to be narrow (spot), wide (flood) or extra-wide (wide flood) as indicated in the fixture description.

- D Tungsten-Halogen Lamps: tubular, quartz, resistant to high temperatures. Guaranteed rated life is to be above 2000 hours and luminous output above the following:
1. 9500 lumens for 500 W lamps
 2. 22000 lumens for 1000 W lamps
 3. 44000 lumens for 2000 W lamps.
- E. Straight Tubular Fluorescent Lamps: to IEC 81 (SSA 138 and SSA 139) and, unless otherwise specified, are to be switch start type, bi-pin, rated as indicated in the fixture description and with improved fluorescent internal coating. Colour of light is to be high colour rendering, cool white. Lamps are to be low energy type with tube diameter 26 mm. Guaranteed rated life is to be above 8000 hours and luminous output above the following:
1. 1300 lumens for 18 W lamps (600 mm long)
 2. 3200 lumens for 36 W lamps (1200 mm long)
 3. 5200 lumens for 58 W lamps (1500 mm long).
- F. Compact Fluorescent Lamps: single ended, compact-miniature lamp, with electronic ballast, consisting of four narrow fluorescent tubes welded together, with integral instant starter and capacitor and with special two-pin plug-in base and socket high colour rendering type, warm white appearances or high colour

rendering cool white appearance. Guaranteed rated life is to be above 5000 hours and luminous output above the following:

1. 600 lumens for 10 W lamps (95 mm long)
2. 900 lumens for 13 W lamps (130 mm long)
3. 1200 lumens for 18 W lamps (150 mm long)
4. 1800 lumens for 26 W lamps (170 mm long).
5. Lamps are to be type PLC as manufactured by Osram, Philips or other equal and approved.

G. Blended – light lamp: is to comprise built in ballast in the form of a tungsten filament connector in series with the discharge tube. Colour temperature is to be 3500 K and has luminous output above the following:

1. 3150 lumen for 160 W lamps
2. 5500 lumen for 250 W lamps
3. 13000 lumen for 500 W lamps

H. High Pressure Mercury Vapour Lamps: to IEC 188, and to include quartz discharge tube in an internally coated ovoid outer tube. Coating is to be yttrium vanadate phosphor with colour temperature of 3300 deg. K. Guaranteed rated life is to be above 8000 hours and luminous output above the following:

1. 3800 lumens for 80 W lamps
2. 6500 lumens for 125 W lamps
3. 14000 lumens for 250 W lamps.

I. High Pressure Sodium Lamps: type SONT (tubular), with guaranteed average rated life (down to 80 %

output) above 10000 hours, and having initial luminous output above the following:

1. 15000 lumens for 150 W lamps
2. 25000 lumens for 250 W lamps
3. 50000 lumens for 400 W lamps
4. 135000 lumens for 1000 W lamps.

J. Metal Halide Lamps: comprising quartz discharge tube enclosed in clear tubular hard-glass outer bulb, operating on same principle as all gas discharge tubes with iodide additives indium, thallium and sodium in the mercury discharge, to increase intensity in three spectral bands; blue, green and yellow- red with high colour rendering. Lamps are to be to IEC 188 with E40 base. Guaranteed average life is not to be less than 10000 hours and luminous outputs, after 100 hours burning, are to be above the following:

1. 32500 lumens for 400 W lamps
2. 90000 lumens for 1000 W lamps
3. 190000 lumens for 2000 W lamps.

K. Permissible base temperature is to be not greater than 250 deg. C, and maximum bulb temperature not greater than 550 deg. C. Lamp burning position for 2000 W, 220 V lamp is to be possible up to 75 degrees.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Generally: install fixtures level, aligned and parallel or square to building lines and at uniform heights as shown on the Drawings or as approved by the Engineer. Make final height adjustment after installation.
- B. Connection box is to be provided for each fixture to carry out the connection in case of two or more wire connection. Connection of wires inside the fixture is not permitted.
- C. Fixture Support: provide fixture and/or fixture outlet boxes with hangers, brackets and flanged bolted fittings, as necessary, to support weight of fixture. Submit details of hangers etc. and method of fastening for approval. Rigidly secure fixtures mounted on outlet boxes to fixture studs. Install hooks or extension pieces, when required, for proper installation. Provide one point of support in addition to the outlet box fixture stud for individually mounted fixtures longer than 600 mm.
- D. Stem Hangers: provide two stem hangers for individually mounted pendant fixtures. Stems are to have suspension aligners and are to be of suitable length for suspending fixtures at required height.
- E. Suspended Ceilings: if ceiling construction is unable to support weight of fixtures without strain or deformation, suspend fixtures directly from building structure.
- F. Solid Ceilings: coordinate dimensions of recesses in ceilings with exact fixture dimensions and structural elements.
- G. Continuous Rows: arrange fixtures so that individual fixtures can be removed without dismantling remaining fixtures. Provide minimum spacing between fixtures.
- H. Cover Plates: install cover plates over fixture outlet box or opening in ceiling or structure when left unused.
- I. Flush Recessed Fixtures: install to completely eliminate light leakage within fixture and between fixture and adjacent finished surface.
- J. Ventilation: keep ventilation channels free after fixture is installed, if required by the design of the fixture. K. Earth metal frames of fixtures as described in "Earthing" Section.
- L. Tightness: ensure that enclosed fixtures are reasonably insect/dust tight when installed, and completely weather- proof for installations subject to weather conditions.
- M. Lamps for Permanent Installation: place new lamps in fixtures immediately prior to hand-over and when instructed by the Engineer. Lamps used for temporary service are not to be used for final lamping of fixtures.

3.3 FIELD QUALITY CONTROL

- A. Visual Inspection: check neatness of installation, uniformity of equipment and nameplates etc. B. Illumination Measurements: to be taken at selected locations, to determine level and uniformity. C. Operation: check lighting installations for operation including control and regulation equipment.
- D. Electrical Data: measure power factor, current and voltage at start for installations with discharge lamps.
- E. Furnish stock or replacement lamps as indicated above, of each type and size lamp used in each

type fixture. Deliver replacement stock as directed to Owner's storage space.

- F. Provide instruments to make and record test results.
- G. Tests: give advance notice of dates and times for field tests. Verify normal operation of each fixture after fixtures have been installed and circuits have been energized with normal power source. Interrupt electrical energy to demonstrate proper operation of emergency lighting installation. Include the following in tests of emergency lighting equipment.
1. Duration of supply.
 2. Low battery voltage shutdown.
 3. Normal transfer to battery source and retransfer to normal.
 4. Low supply voltage transfer.
- H. Replace or repair malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

3.4 ADJUSTING AND CLEANING

- A. Clean interior lighting fixtures of dirt and construction debris upon completion of installation.
Clean fingerprints and smudges from lenses.
- B. Protect installed fixtures from damage during remainder of construction period.

3.5 EARTHING

- A. Provide equipment earthing connections for interior lighting fixtures as indicated in Section "Earthing".
Tighten connections to comply with tightening torques specified in applicable standards to assure permanent and effective grounds.

3.6 DEMONSTRATION

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

END OF SECTION
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