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*Add the following series after Series 7000:*

**8. SERIES 8000: STREET LIGHTING AND TRAFFIC SIGNALS**

- Section 8010: Basic Electrical Requirements
- Section 8110: Raceways and Empty Conduits
- Section 8120: LV Wires and Cables
- Section 8320: Distribution Transformers
- Section 8425: Main L.V. Distribution Boards
- Section 8452: Earthing
- Section 8470: Panel Boards
- Section 8520: Exterior Lighting
- Section 8620: Traffic Signal System

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## SECTION 8010: BASIC ELECTRICAL REQUIREMENTS

### 1.0 GENERAL

#### 1.1 Related Documents

- A. Drawings and general provisions of Contract, including Project General and Supplementary Conditions, apply to this and the other sections of Electrical Specification.

#### 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 "Division (1) General Requirements:

1. General information and requirements
2. Design Conditions
3. Equipment and Materials
4. Submittals.
5. Coordination drawings.
6. Record documents.
7. Operation and 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.
16. Training programs.
17. Manufacturer's services and local representation.
18. Temporary power and lighting.

- B. Scope of Work

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.

Incoming power supply and connection will be provided by Tanzania national Electricity Supply Company (TANESCO) at 11 kV and 50 Hz to the location shown on the drawings.

Contractor shall coordinate and provide all necessary assistance required by other trades to complete the installation, and to the entire satisfaction of the Engineer. Contractor shall be responsible for providing and installing termination kits in the switchgear.

Telephone public exchange lines will be brought into the premises by the Local Telephone Authority (TTCL) 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)"ELECTRICAL REQUIREMENTS FOR MECHANICAL WORKS," for factory-installed motors, controllers, accessories, and connections.

#### 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.

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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.

1. Location of incoming supply shown on the Drawings
2. Space requirements and associated builder's work for the Authority's installations.
3. 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.

E. KWH-Metering: liaise with TANESCO and provide necessary instrumentation, enclosures and accessories required by them to effect a complete KWH-metering installation.

F. Telephone Public Exchange Lines: liaise with the Local Telephone Authority to confirm location of connection of public telephone exchange lines into the premises.

G. Factory testing for locally manufactured/assembled equipment is to comply with the relevant standards' recommendations and to be witnessed by the Engineer.

H. 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.

#### 1.4 Design Conditions

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

Medium voltage	: 11 kV, 3 phase, 3 wire, and low impedance earthed neutral
Low voltage	: 380/220 V, 3 phase, 5 wires, and 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 generators transformers, switchgear, distribution boards/panels, cables, relays, lighting fixtures, switches, circuit breakers, UPS, etc., are to be designed and derated for continuous and trouble free service under the site climatic conditions.

Altitude	: 300 m above sea level
Maximum ambient temperature	: 45 deg.C. (in the shade)
Minimum ambient temperature	: -5 deg.C.
Maximum relative humidity	: 65 - 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 Electrical Specification carry out electrical work in accordance with the current issue of the local codes of practice, regulations of Local

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Electricity Company, latest Edition of the "Regulation for Electrical Installations" (BS 7671) Issued by the "British Institute of Electrical Engineer-IEE".

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
ICAO	: International Civil Aviation Organization
IATA	: International Air Transport 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 motor control centers/panels, cables between motor controllers or motor control centers to motors and other similar electrically operated equipment are shown for information and reference only.

K. KWH, KVAR & Peak Demand Metering: provide necessary equipment, enclosure and accessories required by Local Power Authority to effect a complete KWH, KVAR & Peak Demand 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, allocated space 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 filled 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.

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- 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 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.
  - 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.

## **1.6 Submissions**

- A. General: Follow the procedures specified in Division (1), General Requirements, 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.  
  
Shop Drawings - Initial Submittal: 1 additional blue- or black-line prints.  
Shop Drawings - Final Submittal: 1 additional blue- or black-line prints.  
Product Data: 1 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

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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:
1. Details of electrical installations in conjunction with all trades concerned, showing sleeves and openings for passage through floor structure.
  2. 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.
  3. Plans showing equipment layouts including all details pertaining to clearances, access, sleeves, electrical connections, location and elevation of pipes, ducts, conduits, etc.
  4. 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, 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 Division (1) "General Requirements" 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.

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- 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 Division (1) "General Requirements" Section "PROJECT CLOSEOUT" In addition to the requirements specified in General Requirements, 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 Operation and Maintenance Manuals**

- A. Prepare operation and maintenance manuals in accordance with Division 1 "General Requirements" Section "PROJECT CLOSEOUT" In addition to the requirements specified in General Requirements, 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 reassemble; aligning and adjusting instructions.
  4. Servicing instructions and lubrication charts and schedules.
  5. Complete set of "As. Built" drawings.

### **1.10 Delivery, Storage and Handling**

- A. Deliver products to the project properly identified with names, model numbers, types, grades, and 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.

## **2. PRODUCTS** (Not Applicable)

## **3. EXECUTION**

### **Rough-In**

- A. Verify final locations for rough-in with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in "Site Work" through (16) "Electrical Work" for rough-in requirements.

### **Electrical Installations**

- A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

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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 and overhead 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.

### **Tests on Site**

- A. Generally: In addition to factory tests as specified, 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 and approved 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.

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- 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.

### **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 sets of transparencies 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 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, telex and fax numbers and Email of the manufacturer of every item of equipment
  - 5. name, address, telephone and telex numbers and Email 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.

### 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.

### Maintenance Contracts

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

### Training Programs

- A. Contractor shall provide a training program to the Owner's designated personnel in the proper operation and maintenance of the various electrical systems. The program shall cover operations, planned preventative maintenance, repairs and appropriate measures to be taken during abnormal conditions. Actual "hands-on" training shall be provided.
- B. The program shall be presented by qualified individuals from the equipment manufacturers at times convenient to the Owner.
- C. The cost of training programs to be conducted shall be included in the contract price.

### Manufacturer's Services and Local Representative

- A. Provide the services of a representative or technician from the manufacturer of each system as specified experienced in the installation and operation of the system. Provide evidence that proposed equipment manufacturer has a locally established and authorized organization which can be called upon for professional advice and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements.

Failure to satisfy the Engineer may disqualify a manufacturer.

## 4. MEASUREMENT AND PAYMENT

Item	Description	Unit
<b>SS80.10</b>	<b>Basic Electrical Requirements</b>	
(a) (i)	HT and LV Power Supply: Liaise with TANESCO for power supply connection - Street Lights and Two Traffic Lights.....	Provisional Sum (PS)
(ii)	Allow for contractor's overhead and profit as percentage of sub item 80.10(a)(i).....	Percent (%)
(b)	13 meters height Corrossive Resistant Mid Hinged Street Light Poles as specified.....	Number (no)
(c)	Guard blocks .....	Number (no)
(d)	13 meters height Corrossive Resistant Mid Hinged Poles for CCTV at the Bridge to be installed at both ends and two in the middle as specified	Number (no)

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The tendered rate shall include full compensation for supply, installation, testing, commissioning, putting into satisfactory operation and handing over complete installed systems.

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## SECTION 8110: RACEWAYS AND EMPTY CONDUITS

### 1. GENERAL

#### 1.1 Related documents

- A. Drawings and general provisions of Contract, including Project General and Supplementary Conditions, apply to this Section.
- B. Requirements of the following Division(16)"Electrical Specification" Sections apply to this Section:
  - 1. "Basic Electrical Requirements".
  - 2. "Electrical Testing And Commissioning".

#### 1.2 Summary

- A. Provide labor, materials, equipment and services, and perform operations required for installation of Raceways and related work as indicated on the drawings or specified herein.
- B. This Section includes raceways and empty conduits 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. Rigid heavy gauge UPVC conduit.
  - 6. Flexible UPVC conduit.
  - 7. Wiring and cable trunking
  - 8. Under floor trunking
  - 9. Under ground duct
- C. Related Sections: The following Division(16) "Electrical Specification" Sections contain requirements that relate to this Section:
  - 1. "Cable Trays" for cable tray type raceways".
  - 2. "L.V Wires and Cables" for other wiring methods.
  - 3. "Electrical Cabinets, Boxes and Fittings"
  - 4. "Supporting Devices" for raceway.

In addition to Division (14) "CONVEYING SYSTEMS" and Division (15)"ELECTRICAL REQUIREMENTS FOR MECHANICAL WORKS" Section.

#### 1.3 Submittals

- A. General: Submit the following in accordance with Conditions of Contract and General Specification Sections.
- B. Copy of this specification section where each article stamped (comply or not comply) if applicable
- C. Product Data: manufacturer's catalogues (technical product data), for each type of raceway specified.
- D. Samples: 20 cm long sample of each type and size of surface raceway with required finish.
- E. Installation Instructions: manufacturer's written installation instructions for wireway, surface raceway, and non metallic raceway products.
  - Include data substantiating that materials comply with requirements.
- F. Shop Drawings: submit dimensioned drawings of raceway systems showing layout of raceways and fittings, spatial relationships to associated equipment, and adjoining raceways, if any. Show connections to electrical power panels and feeders. Provide the following:
  - 1. Exact routing of conduits, trunking etc. with indication of boxes, accessories and expansion joints, size

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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.

G. 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 Division (1) "General Requirements" Section.

#### **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.

#### **1.6 Design Criteria**

- A. Conduits
1. Light and power circuits , fire alarm , telephone signal and other low current system wiring and cables feeding receptacles , distribution panels shall be drawn in conduits unless otherwise specified and indicated .
  2. Conduits shall be generally concealed in slabs , walls or in the floor screed
  3. No more than one system shall be combined in the same conduit .
  4. Unless otherwise specified in , shown on the drawing and required by the applicable codes embedded conduits shall be of heavy gauge rigid PVC.
  5. In general galvanized steel conduits shall be used for the following , unless otherwise specified or indicated.
    - a. Exposed installations.
    - b. Above false ceilings .
    - c. Fire alarm system .
    - d. Data and communication system in areas subject to electromagnetic interference .
  6. Minimum size of conduits to be used in this project is 20mm internal diameter.
- B. Trunking
1. Cable trunking shall only be used for indoors.
  2. The wiring capacity shall be in accordance with IEE wiring regulations with 45% space factor.

## **2. PRODUCTS**

### **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, the following:

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Weatland (Steel Conduit)  
Marshall – Tufflex  
Deco – Duct  
**Or equally approved**

(U.S.A),  
(England),  
(U.A.E),

### **Steel Conduit And Tubing**

- A. General: provide steel conduit and fittings of types, grades, weights (wall thickness) and sizes as required for each service indicated. Provide proper selection to fulfill 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, screwed to BS 4568 Part 1 and 2 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. Lockouts: 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.
  5. Expansion Fittings :- Malleable iron-hot dipped galvanized end fittings with grounding strip and flexible tube and covered with neoprene tubing for rigid steel conduit in concrete. The use of aluminum material is prohibited
- C. Intermediate Metal Conduit (IMC): rigid high grade mild strip welded straight, hot dip galvanized 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 and connectors and terminations with rigid coupling, concrete tight where required, and with red lead coated threads where site cut.
- D. Electrical Metric Tubing (EMT): rigid high grade mild strip steel hot dip galvanized 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: threadless, hinged clamp type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated. Fitting shall be specifically approved for use with this raceway.
  2. Straight Terminal Connectors: one piece body, female end having hinged clamp and deep slotted machine screws for securing to conduit, male end having thread and lockout.
  3. Angle Connectors: 45 or 90 degrees terminal angle connectors as specified for straight connectors, except that body is to be two-piece with removable upper section.
- F. 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. Alternatively with cable or conduit bolted pressure sealing components.
  2. Supports and Hangers: galvanized malleable cast iron straps or structural steel sections with hot dip galvanized bolts and nuts. Refer to Section "Supporting Devices" for other requirements.

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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.

### **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 fulfill 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-hygroscopes and non-porous, conforming to IEC 423, 614-1 and 614-2, BS 4607 and BS 6099, or other equal and approved standards. For direct burial PVC ducts shall be schedule 40,90 degrees C. Unless otherwise indicated
  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-hygroscopes 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 bands and Class C where directly buried in ground.
  1. Underground PVC and ABS Plastic Utilities Duct: NEMA TC 6, Type I for encased burial in concrete, Type II for direct burial.
  2. PVC and ABS Plastic Utilities Duct Fittings: NEMA TC 9, mate and match to duct type and material.
  3. Conduit and Tubing Accessories: Provide conduit, tubing and duct accessories of types, sizes and materials, complying with manufacturer's published product information, which mate and match conduit and tubing.
  4. Conduit Bodies: Provide galvanized cast-metal conduit bodies of types, shapes and sizes as required to fulfill job requirements and applicable code requirements. Construct conduit bodies with threaded-conduit-entrance ends, removable covers, either cast or of galvanized steel, and corrosion-resistant screws.

### **Wiring And Cable Trunking**

- 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, Trunking, associated parts and accessories shall be fabricated from hot dipped 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.
  1. Cable trunking and fittings shall have removable lids extending over their entire lengths. The lids shall be of the same material, thickness and finish as those of the trunking.
  2. Cable trunking shall be supported at regular intervals not exceeding 1750 mm on horizontal and 2000mm on vertical runs additional supports at bends angles shall be provided. Manufacturer standard fittings shall be used. Where special fittings or sections of trunking are fabricated, they shall be prepared and finished to the same standard as manufacturer's standard items. Each length

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of the trunking and accessories shall be complete with coupling and earth copper links .

3. The wiring capacity of trunking shall be in accordance with IEE wiring regulation 17 Th. edition .
  4. Connections between trunking apparatus shall be by a screwed conduit coupler , bush and locknut or a standard flanged coupling . Direct attachment of trunking to apparatus will only be permitted if cable entries are provided with bushings and the return edge of the lid of the trunking is left intact .
  5. Metal partitions in trunking and fittings shall be provided as required by the IEE wiring regulations and applicable codes . They shall be of the same material and finish as those of the trunking .
- C. Raintight Trunking : Construct raintight lay-in wireways with hinged covers, in accordance with UL 870 and with components UL-listed, including lengths, connectors and fittings. Design units to allow fastening hinged cover closed without use of parts other than standard lengths, fittings and connectors. Construct units to be capable of sealing cover in closed position with sealing wire. Provide wireway units with knockouts only in bottom of troughs.
- D. PVC Trunking : High impact , heavy duty , self extinguishing rigid PVC with grooved double locking action of the clip or cover. Trunking is to be capable of receiving functional slot in hangers and demountable separators to segregate wiring systems as needed . Cover shall be maximum 1.5 meter in length .
- E. Under Floor Trunking :
1. Type : for installation in floor screed , laid on unfinished concrete floor or under false floor.
  2. Under floor trunking shall be galvanized sheet steel protected by corrosion resistance coating on inside and outside surfaces . Single , double or triple system as required , 3.3m length of 2mm thick .
  3. Under floor trunking shall be supplied with approved standard manufacturer's fittings , couplings adjustable supports , duct to conduit adapter, horizontal 45 and 90 degree bends , vertical 90 degree bends , standard socket outlets .
  4. Junction boxes : flush , cast iron , protected by corrosion resistance coating and suitable for double or triple systems as required and shown on the drawings .
  5. Flash outlet boxes ; factory designed , with necessary accessories to accommodate specific outlets shown on the drawings.
- F. Under Ground Duct :
1. Under Ground Concrete encased duct with conductors shall be routed for all external electrical networks.
  2. Under Ground Concrete shall be design according to civil engineer recommended.
  3. Under Ground Concrete must be water and weather proof.

### **3. EXECUTION**

#### **Inspection**

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

#### **Preparation**

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this section.
- B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this section with the work of related trades so as not to delay job progress.
- C. Provide templates as required to related trade for location of items.

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### **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 manufacturer's 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 20mm diameter, unless otherwise shown on the Drawings.

### **Installation Of Conduits**

- A. General: install concealed conduits in, either in walls, underfloor, in slabs, or above hung ceilings. Follow indications on drawings
  - 1. Mechanically Fasten: conduits and wireways 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. Use roughing dimensions of electrically operated unit furnished by supplier 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).

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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 galvanized 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 galvanized 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/subfeeder runs in non-accessible false ceiling areas, for swimming pool and fountain installations according to NEC, for embedded and exposed installations in hazardous explosive areas.
  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, security, parking, kitchen, fire alarm wiring circuits, 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 precast concrete panels where required.
  4. Use rigid heavy gauge UPVC conduit for embedded (in wall or slab), under- floor, consealed (in dry walls) and above false ceiling installations for lighting, power circuits and low current & communication circuits, unless otherwise indicated or specified.
  5. Use rigid heavy gauge UPVC 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.

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- 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 precuts 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 vapor.
  4. Provide 3 mm galvanized 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 galvanized 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, and in crawl spaces
  6. Pull box shall be provided in all conduits runs exceeding 20m in length or containing more than two right - bends .
  7. Conduit boxes, both standard and adaptable shall be fixed to the structure or the building independently of the conduit.
  8. No burr shall be left on the conduit ends after cutting and screwing. All joints in assembly of conduit shall be treated immediately after installation with cold galvanized.
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G. Heavy Gauge PVC Conduits:

1. Make solvent 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.(Use smooth brass bushing for termination of the conduits).
3. Install insulated type bushings for terminating conduits 32mm and larger. Bushings are to have flared bottom and ribbed sides, upper edge to have phonemic 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.

### **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.(Do not support raceways from duct work).
- 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.
- G. All metallic cable trunking shall be bonded to the earthing system using separate earthing via insulated cable not less than 4 sq.mm. .
- H. All trunking and supports shall be free from rust patches or mechanical damage. All abrasions on metallic paint shall be repaired immediately after the trunking has been installed .
- I. Cables shall not be installed in trunking until the section is complete .
- J. Each group of cables comprising a circuit shall be secured at 300mm intervals for vertical runs & 1200mm for horizontal run with approved type non metallic buckles . The circuit reference of each group shall be identified with an approved type of label , spaced at 1800mm.
- K. Trunking passing through walls and ceilings is to have cover fixed solidly for 25mm either side of walls and for 150mm either side of floor and ceilings.

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**4. MEASUREMENT AND PAYMENT**

<b>Item</b>	<b>Description</b>	<b>Unit</b>
<b>SS81.10</b>	<b>Raceways and empty conduits</b>	
(a)	Sleeve / conduit for power circuit (100mm diameter) .....	Meter (m)
(b)	Sleeve / conduit for signalling circuit for road sections at the bridge (40mm diameter) .....	Meter (m)

The unit of measurement shall be the meter of sleeves / conduits installed.

The tendered rate shall include full compensation for supply and installation, including transportation, excavation, back filling, splicing materials, terminations and warning tape. The unit price includes all accessories and fittings to complete the work in a neat workmanlike manner. All road crossings are inclusive in the tendered rate.

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## SECTION 8120: LV WIRES AND CABLES

### 1. GENERAL

#### Related Documents

- A. Drawings and general provisions of Contract, including Project General and Supplementary Conditions, apply to this Section.
- B. Requirements of the following Division (16) "Electrical Specification" Sections apply to this section:
  - 1. "Basic Electrical Requirements."
  - 2. "Electrical Testing and Commissioning".

#### Summary

- A. Provide labor, materials, equipment and services, and perform operations required for installation of L.V. wire and cable and related work as indicated on the drawings and specified herein.
- B. This section includes wires, cables, and connectors for power, lighting, signal, control and related systems rated 600 volts and less.
- C. Extent of electrical wire and cable work is indicated by drawings and schedules.
- D. 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.
- E. Applications of electrical L.V. wires, cables, 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.
- F. Related Sections: the following sections contain requirements that relate to this section:
  - 1. Division (16) Section "Electrical Cabinets, Boxes and Fittings" for connectors for Terminating Cables in boxes and other electrical enclosures.
  - 2. Division (16) Section "MV Cables" for medium voltage distribution.
  - 3. Division (16) Section "Fire Alarm System Specifications (to be released later): for fire alarm cables.

#### Submittals

- A. Product Data: submit manufacturer's data (latest published literature) 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:
  - 1. Constructional details, standards to which cables comply, current carrying capacities, derating factors for grouping and temperature.
  - 2. Manufacturer's catalogue cuts.
  - 3. Dimensional and electrical characteristics.
  - 4. Samples of each cable and wire and, if requested by the Engineer, other accessories.

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- 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 transformers, switchboards, panelboards etc.
  4. Details of terminations, splices and tapings 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.

### **Quality Assurance**

Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.

- 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. Design Criteria: 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. The contractor shall 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. A copy of the relevant standards in the English language shall be submitted.
- 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.

### **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 abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

## **2. PRODUCTS “MATERIALS”**

### **Manufacturers**

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

BICC

Wire and Cable:  
(England/Korea)

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**Or equally approved**

**Wires And Cables**

- A. Provide wire and cable for the temperature, conditions and locations where installed
- B. 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<sup>2</sup> and above, based on IEC 228 Class 2. 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 and above are to be compacted. Multi-core cables 35 mm 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. Color codes and Identifications (Building wires): in the absence of a national code/regulation, insulation is to be colour coded or otherwise identified as follows:
    - Neutral is to be black
    - Protective earth is to be green or green/yellow striped
    - Phase colours are to be selected in accordance with local regulations and IEC standards, where not in contradiction with the local regulations.
    - Control cables shall be identified by numbering system engraved on insulation.
    - Telephone, data and communication shall be colour coded as manufacture's standards and regulations.
  3. All cables and wires must be of low smoke zero halogen LOSH type.

**LV Wires:**

1. Single Core PVC Insulated unarmored cables (Building 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/E to IEC 227 BS 6746(type 5), suitable for wet locations and for conductor temperature of 70 deg. C. Wires are to be 450/750 V grade.

**LV Cables:**

1. Single Core XLPE Insulated, LSOH, Cables (0.6/1KV) :
  - Conductor : annealed stranded copper
  - Insulation : cross link polyethelene XLPE.
  - Over sheath : PVC black .
  - Conductor Temperature : 90 deg.C. max .
  - Standards : IEC 502 .Armored cables are to have taped bedding with single wire aluminum armor.
2. Multi Core XLPE Insulated, LSOH, (0.6/1KV) Cable
  - Conductor : Annealed stranded copper conductor .
  - Insulation : Cross -linked polyethylene XLPE to IEC 502 .
  - Conductor temperature : Up to 90deg. C .
  - Laying up : The cores are laid up with right hand lay , where necessary, synthetic fillers are used to maintain circularity .
  - Bedding : extruded PVC layer .
  - Over sheath : extruded layer of PVC with PVC , black color.
  - Standards : IEC 502 and BS 5467 .

Armoured cables are to have single layer of galvanized steel wire and over sheath

3. Flexible, LSOH, Cable for Connection to Appliances, Window Fans, Pendants etc.: are 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 Cable: solid or stranded plain annealed copper conductors to BS 6360 (in sizes up to 4 mm<sup>2</sup>), extruded silicon rubber insulation to BS 6889 (0.6 mm radial thickness),

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aluminum/PVC laminate and PVC composite sheath with tinned earth continuity conductor/drain wire. Cable is to be rated 300/500 V, capable of accepting voltage surges up to 5 kV, to operate continuously at 150 deg. C. and for short duration's at 200 deg. C. It is to be certified to have passed IEC 331 and IEC 332 flame resistance and fire retardant tests.

5. High Temperature Cable: plain copper stranded circular conductor complying with BS 6360, Mica/Glass Fire resistant tape covered by extruded cross-linked insulation comply with BS 7655 operating temperature 90°C, cables is to be rated 600/1000 V. It is to be certified to have passed IEC 331, BS 6387 categories CWZ, and IEC 332-1 flame resistance and fire retardant test. Cables are to be used to feed the fire pumps, and other similar loads as shown on the drawings.
6. Mineral Insulated Cables:
7. Shall be used where indicated or shown on the drawings . The contractor may propose such cables for approval for certain applications and areas i.e. mechanical rooms ...

The cables shall comply with the followings :-/

Compliance to BS 6207 part 1 , rated 600/1000 V. Cable shall comprise of a pressure packed magnesium oxide insulation contained within a continuous soft ductile copper sheath and copper conductors embedded in the dielectric in standard formation.

Conductor shall be of solid , high electrical conductivity copper .

Each conductor shall be identified with regard to phase by means of sleeving placed over the neoprene insulation .

Cables shall be shipped with ends sealed against moisture ingress .

Cable shall be 2 hours fire resistive rating and shall be suitable for installation in hazardous location classes I,II,III and "General Requirements" and "Site Work" and for fire pumping wiring cables embedded in concrete shall have an overall PVC jacket.

Termination fastenings and supports, stripping and crimping tools , threaded glands , end seals and sealing compound shall be provided.

### **Control and Signal Cables**

1. Multicore PVC Insulated Control Cables: 0.6/1 kV rating, solid 1.5 mm, 2.5 mm or stranded 4 mm plain circular copper conductors, with heat resistive PVC/E to IEC 227 (PVC type 5 to BS 6717), rated for 85 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. Armored 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 502, 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.

### **Connectors for conductors (LV Power)**

1. Provide factory-fabricated, solderless metal connectors of sizes, ambacity ratings, materials, types and classes for applications and for services indicated to BS standards or equal. Use connectors with temperature ratings equal to or greater than those of the wires upon which used. Connectors shall be two hole type to prevent swiveling.
2. Wire and Cable Connectors - Indent or Twist On: (Conductor-type A-1) Pressure indent type for conductors and splices 10 sq.mm. and smaller, manufactured from pressed non-ferrous material applied to conductor by mechanical crimping pressure and covered with an insulating cover, or electrical spring connector rated 600 volt twist-on type with metal spring, steel shell and color-coded long skirted, polyvinyl chloride insulator. Connectors shall be rated 600 volts, 105 degrees C ambient.

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3. Wire and Cable Connector - Twist-On: (Conductor-type B-1) Electrical spring connector for connecting 10 sq.mm.cable and smaller, rated 600 volts, 105 degrees C ambient, consisting of metal spring, steel shell and color coded, long skirted polyvinyl chloride insulator.
  4. Wire and Cable Connector - Bolted: (Conductor-type A-2) Bolted pressure type for conductors 16sq.mm and larger, manufactured from non-ferrous copper alloy material, applied to the conductor by clamping with a minimum of two bolts, and provided with a phenolic insulating cover rated 600 volts.
  5. Wire and Cable Connector - Compression: Compression conductors for conductors 16 sq.mm. and larger, manufactured from non-ferrous copper alloy applied to conductor by mechanical crimping pressure and insulated for 600 volts.
  6. Wire and Cable Tags - Manholes: Sheet lead or zinc to accommodate lettering as indicated on drawings. Secure tags with a tinned copper wire to cables in manholes, identifying cables with building and/or equipment served.
  7. Wire and Cable Tags - Self-Adhering: Waterproof tape, fungus resistant, high adhesion and tensile strength.

### **3. EXECUTION**

#### **Examination**

- A. Examine conditions at the job site where work of this Section is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

#### **Preparation**

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this Section.
- B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this Section with the work of related trades, so as not to delay job progress.
- C. Provide templates as required to related trade for location of items.

#### **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, sheaves, winches, ductentrance tunnels which will not damage cables or raceway. Do not use rope hitches for pulling attachment to wire or cable.
- 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.

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- 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 and obtain the Engineer approval prior to splicing. In case of splices, these are to be inside splice boxes, pull or junction boxes.
  - K. Install splices and tapes connectors which possess equivalent-or-better mechanical strength and insulation ratings than conductors being spliced. Where feeder conductors are connected in parallel, taps shall be connected to conductors corresponding to phases, neutrals and grounds.
  - 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 torque's 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.
    - 1. Connectors for terminating or making T-taps and splices are to be Type A-1 on conductors 10 mm<sup>2</sup> or smaller, Type A- 2 for conductors 16 mm<sup>2</sup> and larger, and Type B-1 for branch circuit and fixture wiring.
    - 2. Provide approved connectors to BS/IEC specifically for armoured cables.
  - 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 mm<sup>2</sup> 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 mm<sup>2</sup> and larger are to terminate in tunnel lugs with set-screw, or by using bolted or sweated compression connectors.

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Z. Tagging: tag main and feeder cables in pull-boxes, wireways and wiring gutters of panelboards or distribution cabinets. With wire and cable tags, self-adhering 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.

### **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 galvanized 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 galvanized cast steel clamps (or moulded plastic or die cast Aluminum 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 800 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 finishing.

H. Buried cables liable to mechanical damage are to be drawn through PVC conduit or asbestos cement pipe. If steel conduit is a used, all three-phase conductor, 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 meters. 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.
- Q. Arc Proofing of Cables: Arc-proof cables within enclosures, switchgear and substation cubicles, pull boxes and manholes. Clean cables of dirt and other foreign matter. Starting 12 mm from the entering conduits or ducts (to prevent interference with inherent cable expansion and afford cable inspection) wrap arc and fireproofing tape over cable with a minimum of 7 mm overlap. Apply a second layer of the same tape overlapped 7 mm with joints occurring midway between the joints of the first layer. Secure arc and fireproofing tapes in place by random wrapping with glass cloth electrical tape.

A.A Cable Glands:

1. All cables shall be fitted with cable glands to BS 6121. Glanding of cables shall be carried out strictly in accordance with the manufacturer's instructions and the correct sizes of metric cable glands and adapters (if required ) shall be used on each cable end .
2. PCP (polychloroprene ) shrouds shall be supplied and installed on cable glands .

A.B All cables shall be adequately supported and clipped to within 200mm of the cable glands at both ends .

A.C Where cables are run on tray/rack , cable ties and cleats/clamps shall be used at intervals as follows:-

Maximum spacing of clip/cleats/tie - wraps

Overall Diameter of Cable	NON-armoured cable		Armoured cable	
	Horizontal	Vertical	Horizontal	Vertical
Mm	mm	mm	mm	mm
<9	250	400	---	---
>9<15	300	400	350	450
>15<20	350	450	400	550
>20<40	400	550	450	600
>40	800	800	800	800

R. Mineral Insulated Cable Installation: Install cable in accordance with the manufacturer's instructions and the following:

1. Storage and Handling
  - a. Store cables in a dry location.
  - b. When cables are cut in the field, the ends shall be immediately sealed using approved sealing compound and PVC tape.
  - c. Cable shall be uncoiled by rolling or by means of a supply reel rather than pulling from the periphery or the center of the coil to prevent snarling and kinking.
  - d. Precautions shall be taken to prevent damage to the cable from blows with sharp instruments and pulling over sharp objects.

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### **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, handholds or manholes.
- B. Joints in flexible cables and cords are not permitted
- C. 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.
- D. Where Joints are unavoidable:
  - 1. 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. All 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.
  - 2. For PVC/PVC & XLPE cables , cast resin moulded type joints shall be used. The jointed cores shall be insulated by means of several wrappings of tapes as recommended by the manufacturer . The cable armouring shall be made continuous within the joint by means of bonding tape and clamps .
  - 3. Complete joints and termination in the shortest time to the Engineer Approval.
  - 4. Fill joints with compound filling in stages to allow the material to flow .
  - 5. Joints shall be made by means of tinned copper connectors compression type or equal approved .
  - 6. Ensure sealing compounds are poured at the correct temperature .
- E. Cutting tools for jointing and terminating cables are to be purpose made, to prevent damage to insulation in general, and to cable sheathing..
- F. Cleaning of lacquer on conductors is to be by use of sponge and white spirit.

### **Field Quality Control**

- A. Cable tests are to be carried out in accordance with the requirements of the Regulations and Standards. Cables shall be tested on the cable drums prior to removal to the work site.
- 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.

**4. MEASUREMENT AND PAYMENT**

<b>Item</b>	<b>Description</b>	<b>Unit</b>
<b>SS81.20</b>	<b>LV Wires and Cables</b>	
(a)	3cx16mmsq pvc xlpe armoured cable of 11kV HT Underground Cable from nearby 11kV Power Line to the Transformer.....	Meter (m)
(b)	4cx50mmsq of xlpe armoured cable of 400/200V underground cable from Transformer to Main Distribution Board.....	Meter (m)
(c)	4cx25mmsq of xlpe armoured cable of 400/200V underground cable from Main Distribution Board to Street Light Poles.....	Meter (m)
(d)	2cx2.5mmsq heat resistant cable.....	Meter (m)
(e)	4cx25mmsq of xlpe armoured cable of 400/200V underground cable from nearby Power Line to Traffic Light DBs.....	Meter (m)
(f)	4cx25mmsq of xlpe armoured cable of 400/200V underground cable from nearby Street Light Pole to BD3 (at the bridge).....	Meter (m)
(g)	3cx4mmsq xlpe armoured cable for bridge lightings.....	Meter (m)
(h)	4cx25mmsq xlpe armoured cable for CCTV and Communication Equipment from DB6	Meter (m)
(i)	4cx25mmsq xlpe armoured cable for CCTV and Communication Equipment from DB2	Meter(m)

The unit of measurement shall be the meter of L.V. wire and cable installed.

The tendered rate shall include full compensation for supply, installation, testing, commissioning, putting into satisfactory operation and handing over complete systems of low voltage cable with insulation including transportation, excavation, back filling, splicing materials, terminations, warning tape, continuous brick & grounding. The unit price includes all accessories and fittings to complete the work in a neat workmanlike manner.

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## SECTION 8320: DISTRIBUTION TRANSFORMERS

### 1. GENERAL

#### Related Documents

- A. Drawings and general provisions of the Contract, including Project General and Supplementary Conditions, apply to work in this section.

#### Summary

- A. Provide labor, materials, equipment and services, and perform operations required for install of distribution transformers and related work as indicated on the drawings and specified herein.
- B. This section includes distribution transformers with medium-voltage primaries. Types of transformers specified in this Section include the following:
1. Dry type cast resin impregnated
  2. Liquied filled transformers (insulation oil transformers).
- C. Related sections : the following Sections contain requirements that relate to this Section:
1. Division (16) "Electrical Work" Section "MV Switchgear" for coordination of protection.
  2. Division (16) "Electrical Work" Section "MV Cables" and Section "L.V Wires and Cables" for terminal connections
  3. Division (16) "Electrical Work" Section "Main L.V Distribution Boards" for coordination of protection.
  4. Division (16) "Electrical Work" Section "Electrical Testing And Commissioning".
- D. "Dry Type" refers to "cast resin dry type" unless otherwise specified.

#### Quality Assurance

- A. Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.
1. Regulatory Requirements: Comply with provisions of the applicable electrical code, and concerned electric authority regulations.
  2. Standards:
    - Dry type transformer shall be in compliance with IEC 726 latest Revision .
    - Oil filled transformers shall be in compliance with IEC 76 or BS 171
    - The individual components associated with transformers shall be in accordance with relevant IEC latest edition .
    - Safety regulations : In accordance to IEC and NFPA.
    - If the manufacturer standards deviates from these standards , the differences should be clearly outlined and copy of the standards to be submitted .
    - In case of difference between applicable standards the most tight should be applied.

#### Submittals

- A. General: submit the following according to the Conditions of the Contract and General Requirements Specification Sections.
- B. Product data for each product specified, detailed description of construction, including dimensioned plans, sections, and elevations. Show minimum clearances and installed devices and features, weight and bearing forces, incoming and outgoing terminals and provisions for feeder terminations.

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- C. Wiring diagrams of transformers and accessory components, differentiating between manufacturer-installed and field-installed wiring and cabling.
  - D. Type test certificates are to be submitted to verify compliance with relevant Standards for each main unit or piece of equipment.
  - E. Type test certificates in general are to include lightning impulse withstand, power frequency voltage, temperature rise, short time current withstand and enclosure protection to IEC 529 for all main equipment.
  - F. Routine Tests: each complete main unit or piece of equipment is to undergo routine tests at the manufacturer's works in accordance with the relevant Standards. Submit routine test reports, prior to shipping equipment, indicating ambient test conditions and guaranteed rating of equipment under site conditions.
  - G. Routine tests and special tests for transformers are to include measurement of noise level, winding resistance, voltage ratio, check of polarity/vector group, impedance voltage, load loss, no-load loss, no-load current, applied and induced over voltage withstand test and separate source voltage withstand test.
  - H. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include a list of relevant completed projects with project names and addresses, and names and addresses of the respective Engineers and Owners.
  - I. Shop and construction drawings including foundation details, grouting holes, base frames and installation details.
  - J. Operation and maintenance data for materials and products to include in the "Operating and Maintenance Manual" specified in General Requirements.
  - K. Field test reports of tests and inspections conducted according to Part 3 of this Section.

#### **Unusual Operating Conditions**

- A. Harmonics :
  - 1. Transformers feeding induction motors shall have the specified rating while supplying a load with possibly total harmonic distortion (THD) of 5% minimum.

#### **Factory Witness Test**

- A. Factory Testing: at least 25% of the of transformers to be supplied are to be witnessed by the Engineer. Selection of transformers for witness test will be randomly carried out by the Engineer and is to cover all ratings to be delivered.
- B. Witness Test: is to include complete routine and special testing including all tests specified by item 1.04-G above on all units to be witnessed, in addition to impulse, partial discharge and temperature rise test on one unit of each rating. Test procedure and program are to be submitted for approval prior to test conduction.
  - 1. The following test shall be performed on transformers at the factory:
    - a. Resistance measurement of windings.
    - b. Ratio tests on the rated voltage connection and on tap connections.
    - c. Polarity and phase-relation tests on the rated voltage connection.
    - d. No-load loss at rated voltage on the rated voltage connection.
    - e. Exciting current at rated voltage on the rated voltage connection.
    - f. Impedance and load loss on rated connection.
    - g. Applied potential tests.
    - h. Induced potential tests.

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2. The following test shall be performed on oil filled transformers at the factory:
    - a. Routine tests according to IEC 76 , and as follows :
      1. Measurement of winding resistance .
      2. Ratio , polarity and phase relationships
      3. Impedance voltage .
      4. Load losses .
      5. No - load losses .
      6. Induced over voltage withstand .
      7. Separate source voltage withstand.
      8. Insulation resistance .
      9. Pressure test oil samples .
      10. Moisture content of oil samples .
    3. Certified test reports on electrically duplicate transformers shall be submitted with approval drawings documenting that the following tests have been performed:
      - a. Temperature tests to verify design criteria.
      - b. Impulse tests on terminals including reduced full-wave, chopped wave and full wave tests.
      - c. Short circuit capability tests.
      - d. Dielectric tests including applied potential and induced potential.
      - e. Sound level tests.
      - f. Tests of mechanical components.

## 2. PRODUCTS

### 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 the following:
- B. Manufacturers
  - General Electric (U.S.A)
  - ABB (Sweden/Germany)
  - Or equally approved.

### Materials

- A. Except as otherwise indicated, provide manufacturer's standard materials and components as indicated by published product information, designed and constructed as recommended by manufacturer and as required for installation.
- B. Dry Type Transformers:-
  1. Transformer shall be of the ventilated dry type, 3 phase, 50 HZ, two winding type with delta primary and wye secondary windings, mounted in a ventilated metal enclosure for indoor installation.
  2. Ratings in KVA and voltage characteristics shall be as indicated on drawings or as specified.
  3. Transformers are designed to ensure that the permitted temperature rise according to IEC 726 is not exceeded. The average temperature rise must not exceed at both high and low voltage windings 80 degree above ambient temperature of 50 degrees C when operating at full load. Transformers shall have class H insulation system .

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4. The HV winding shall be designed as follows

For 11/0.38 kv transformer of power frequency withstand voltage 33 KV and impulse withstand voltage, full wave (1.2 / 5 micro second) of 75 KV as per IEC 726

5. Secondary winding shall be designed for a short duration power frequency test voltage 2-5 KV for rated voltage 380/220V. Secondary winding shall be wye connected with neutral solidly grounded through removable link. Links and connectors shall have a continuous current rating at least equal to the fan cooled rating of the transformer. In the case of transformers with 380/220 volt Y windings, the transformer neutral terminal shall also be brought out into the secondary bus transition of connection to the neutral bus of the secondary switchgear.
6. Transformer impedance shall not be more than 6% with tolerances as per IEC .
7. For 11/0.38 kV transformer tapping is to be provided on HV side by means of reconnectable links (off- circuit), giving  $\pm 2.5\%$  and  $\pm 5\%$  tapping on transformers.
8. Transformers shall be provided with fans for forced air cooling to increase the self-cooled kVA rating by 25%. Power for operating fans shall be taken from a control power transformer to be located in the secondary bus transition or secondary distribution section.
9. A front accessible winding temperature control panel shall be provided equipped with necessary controls for operation of the fans when the self-cooling kVA is exceeded and shall include the following:
- Winding temperature indicator.
  - Fan position selector switch, hand-off-auto.
  - Fuses.
  - Green light (auxiliary power "on").
  - Amber light (fan operation).
  - Red light (excessive temperature).

Auxiliary normally open spare contacts shall be provided to transmit remote alarm signals for fans running and high temperature. Contacts shall be wired to accessible terminals in the secondary bus transition or secondary distribution section.

10. Transformer sound levels shall not exceed IEC standard levels for either self-cooled or fan cooled operation.
11. The core shall be visibly grounded to the frame by means of a flexible grounding strap.

Rear and front enclosure panels shall be removable, fastened down with bolts and captive nuts. Closure panels shall include louvered or screened openings for ventilation. Location of such openings shall be limited to front and rear panels only. There shall be no openings in top panels. Mesh of screened openings or louvers shall be fine enough to prevent accidental contact with interior parts. Housing shall be thoroughly cleaned and degreased after fabrication, bonderized and primed with zinc chromate. Finish shall be two coats of light gray enamel, ANSI color designation No. 61 to match the incoming and outgoing sections of the unit substations.

Windings:

The windings shall be fully insulated for continuous working at the specified service voltage

a) H.V. Windings:

The high voltage winding shall be wound with copper conductor material and impregnated in quartz reinforced epoxy-resin. The high voltage windings shall be interconnected by interconnection pieces with similar insulation or by other approved method.

Tappings shall be arranged at such positions on the H.V. winding as will preserve, as far as possible, the electromagnetic balance of the transformer at all voltage ratios, but shall also be positioned with due regard to the impulse voltages which may be impressed on the

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windings.

b) L.V. Windings:

The low voltage windings shall be wound with copper conductor material, impregnated in reinforced epoxy-resin and provided with appropriate terminals for direct connection to the cable box.

12. H.V. Termination:

H.V. Termination shall comprise 3 pole air insulated cable box.

13. L.V Termination:

The L.V. Termination shall comprise 4 pole air insulated cable box with detachable gland plate, complete with brass compression glands for receiving and terminating busducts or cables with flexible copper conductors.

14. Temperature Indicator:

The preferred temperature-sensing device would have a positive linear characteristic and be moulded into the LV coil or coils to measure the hot spot temperature. The manufacturer would determine and select the point of measurement.

The sensing device would be used in conjunction with an analogue or digital indicator, which would continuously display the actual temperature and also indicate the highest temperature reached. The highest temperature indication shall be retained until it has been reset by hand. It shall be possible to reset the indicator without opening the indicator case.

15. Fire Safety:

The transformer shall be manufactured using only non-flammable and self-extinguishing or hard to ignite material. When involved in a fire the transformer shall not emit any toxic gases and the transformer shall extinguish itself within a few minutes after withdrawing the fire source.

The tenderer shall submit with his offer test certificates/reports from a recognized testing institution on a Fire Withstands test carried out on a similar transformer.

16. Provide Surge arrestors on the medium voltage side with surge counters.

17. Provide diagrammatic stainless steel nameplate mounted on the front enclosure panel

18. Provide for lifting and jacking the core and coil assembly.

19. Provide standard elastomer pad isolators to isolate the core and coil structure from the enclosure and base structure.

20. Painting :

The painting of the metal parts which have not received a protective treatment shall comply with the following :-

a) The paints used , both inside and out side , will be anti - fire and will have a low calorific value.

b) Cycle of painting : Degreasing , pickling, phosphating drying in furnace, electrostatic deposit of episodic dust, polymerization and backing in furnace 180 deg. plane roof indoor steel plate shall be treated with anti-condensation paint too .  
Colour of external paint gray RAL 7032 .

C. Oil Filled Transformer Conservator Type

1. Where specified and shown on the drawings oil filled transformer (indoor/ outdoors) 3phase , two winding conservator type, shall be provided.

2. Transformer enclosure shall be rated 100% continuous operation under site ambient conditions, 50 degrees ambient temperature.

3. Standards: The transformer shall be in accordance with the latest edition of IEC 76 or equal approved international standards.

4. The transformer enclosure shall be welded joint steel plate construction complete with external

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cooling tins and the following fittings:

- a. Conservator tank complete with oil level gauge, supply line plug, drain plug, mounted steel brackets.
  - b. Buchholz relay fitted with alarm & trip switches.
  - c. Valves to isolate and bypass Buchholz relay.
  - d. Oil sealed silica-gel breather.
  - e. Two dial thermometer, fitted with maximum reading, one set of alarm contacts and one set of trip contacts. One dial thermometer shall read top oil temperature and the other shall read winding hot spot temperature.
  - f. Oil drain valve and valve connections for a filter heater unit.
  - g. Lifting eyes to lift the complete transformer and conservator tank
  - h. Stainless steel rating and connection diagram plates.
  - i. Stainless steel identification name plate.
  - j. One hand operated, external, five position of circuit tapping switch in the primary winding 2-1/2 percent taps.
  - k. HV & LV terminal air insulated boxes, IP55 sized to accommodate cables number and sizes according to drawing and schedules. Top or bottom entry as indicated.
  - l. Two frame earthing terminals drilled and tapped for M 12 set screws.
  - m. The under carriage shall be of steel plate rigidly constructed and fitted with flange rollers.
5. The main tank, complete with cooling radiators shall be hot dipped galvanized and finished in accordance with manufacturer painting procedure to withstand site conditions.
  6. Oil - the insulating oil shall be mineral oil class 1 to BS 148 or IEC 296.
  7. Noise level of transformer under any mode of operation shall not exceed 70 dBA .
  8. Magnetic core shall be manufactured from cold rolled grain oriented steel, low loss.
  9. Winding to be copper, class B insulated unless otherwise approved , operating normally at 50/65 rise above 50 C degree ambient. The primary and secondary winding ends shall be brought out to clearly identified terminals. All internal winding connections shall be brazed, or solder connections shall not be used, windings shall be uniformly insulated.
  10. Neutral point to be brought out fully rated.
  11. Insulation level for HV & LV winding in accordance with IEC 76 .
  12. Impedance voltage shall be according to IEC standards unless others indicated or specified.
  13. Cooling ,ONAN unless otherwise indicated, with provision for installing cooling fans to increase transformer capacity by 25% . Adjustable thermostats in the main tank top oil for controlling the fans future. The setting range shall be 70 - 120 deg .
  14. Phase relationship (Vector group) Dyn 11 .
  15. Each transformer shall be designed for overloading in accordance with IEC 354 .
  16. Provide Surge arrestors on the medium voltage side with surge counters.

D. Guarantee Schedule:

1. rated power	As shown on the drawings, with fans for extra power as described in item 2.02 above	
2. frequency	50 Hz	
3. highest voltage for equipment:	12kV	for HV side
UM (rms)	600 V	for LV side
4. rated voltage:		
HV side (primary)	11 KV	
LV side (secondary)	380V	

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5. winding connections	Dyn 11 neutral insulated and brought out
6. impedance voltage at rated current	According to IEC standards
7. rated power frequency withstand voltage	30 KV for HV side 2-5 KV for LV side
8. lightning impulse withstand voltage	75 KV at HV side for 11/ 0.38 KV (or according Local Electric regulation)
9. short-circuit apparent power of the system at location	500 MVA for 11/0.4 KV (or according Local Electric regulation)
10. duration of short- circuit withstand	2 seconds
11. terminal connections; MV side	Cable sealing ends, suitable for bottom entry cables or top entry cables

### 3. EXECUTION

#### Examination

- A. Examine conditions at the job site where work of this Section is to be performed to insure proper arrangement and fit of the work. Start of work implies acceptance of job site conditions.

#### Preparation

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this Section.
- B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this Section with the work of related trades so as not to delay job progress.
- C. Provide templates as required to related trade for location of items.

#### Installation

- A. Install transformers where indicated, complying with the manufacturer's written instructions, applicable requirements of the applicable electrical code, and standards, and in accordance with recognized industry practices to ensure that products fulfill requirements.
- B. Install units on vibration mounts; comply with manufacturer's indicated installation method.
- C. Connect transformer units to electrical wiring system; comply with requirements of specification.
- D. Contractor shall set transformer taps to provide the voltage specified on the drawings. Contractor shall recheck voltage after building is occupied and change taps where required to provide the specified voltage as shown on the drawings.
- E. Tighten electrical connections 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 torque specified in UL Std 486A and B.
- F. Grounding: Provide grounding connections for distribution transformers as specified. Tighten connections to comply with tightening torque specified in UL Std 486A to assure permanent and effective grounds.

#### Field Quality Control

- A. Manufacturer's Field Services: arrange and pay for the services of a factory- authorized service representative to supervise the field assembly and connection of components, and the protesting and adjustment of transformer components and accessories.

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- B. **Protesting:** after completing system installation, perform the following preparations for tests:
    1. Make insulation-resistance tests for transformers.
    2. Make a continuity test for windings and remote alarm circuits.
    3. Provide a set of Contract Drawings to the testing agency.
    4. Provide manufacturer’s installation and testing instructions to the testing agency.
  - C. **Independent Testing Agency:** provide services of an independent electrical testing agency according to the requirements of General Requirements “Quality Requirements” to perform tests on medium-voltage transformer installations.
  - D. **Test Objectives:** to ensure transformer installation complies with Contract Documents, is operational within industry and manufacturer’s tolerances, and is suitable for energizing.
  - E. **Test Label:** upon satisfactory completion of tests for each transformer, attach a dated and signed “Satisfactory Test” label to the unit.
  - F. **Schedule tests** and provide notification at least one week in advance of test commencement.
  - G. **Report:** submit a written report of observations and tests. Report defective materials and workmanship.
  - H. **Tests:** include the following minimum inspections and tests according to the manufacturer’s instructions. For test method and data correction factors, conform to applicable Standard .
    1. Inspect accessible components for cleanliness, mechanical, and electrical integrity, for presence of damage or deterioration, and to ensure removal of temporary shipping bracing. Do not proceed with tests until deficiencies are corrected.
    2. **Dry-Type Transformers:** include internal inspection through access panels and covers.
    3. Inspect bolted electrical connections for tightness according to manufacturer’s published torque values or, where not available, those of applicable standards.
    4. **Insulation Resistance:** perform megohmmeter test of primary and secondary winding-to-winding and winding-to-ground according to the following:

WINDING RATING (VOLTS)	MINIMUM TEST VOLTS (d.c)	MINIMUM INSULATION RESISTANCE (MEGOHMS)	
		DRY TYPE	Liquid Filled
0 – 600	1000	500	100
601 –5.000	2500	5000	1000
5.000 – 35.000	5000	25000	5000

- a. **Duration of Each Test:** 10 minutes.
- b. **Temperature Correction:** correct results for test temperature deviation from 20 deg C standard.
- 5. **Turns Ratio:** measure between windings at each tap setting. Measured ratios deviating more than 0.5 percent from the calculated ratio or the measured ratio for adjacent coil are not acceptable.
- 6. **Winding Resistance:** measure for winding at nominal tap setting. Measured resistance deviating more than 1 percent from that of adjacent winding is not acceptable.
- 7. **Over-potential Tests:** apply between high and low voltage and ground at not over 85 percent of factory test value for 1 minute.
- I. **Test Failures:** compare test results with specified performance or manufacturer’s data. Correct deficiencies identified by tests and retest. Verify that transformers meet specified requirements.

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**Adjusting**

- A. After completing installation and cleaning, touch up scratches and mars on finish to match original finish.
- B. Adjust transformer taps to provide optimum voltage conditions actualization equipment throughout the normal operating cycle of the facility. Record voltages and tap settings to submit with test results.

**Demonstration**

- A. Training: arrange and pay for the services of a factory-authorized service representative to demonstrate transformers and accessories and train owner’s staff. Include a minimum of 8 hours of training in operation and maintenance. Provide both classroom training and hands-on equipment operation covering the following:
  - 1. Safety precautions.
  - 2. Features and construction of project transformers and accessories.
  - 3. Routine inspection, test and maintenance procedures.
  - 4. Routine cleaning.
  - 5. Features, operation, and maintenance of integral disconnect and protective devices.
  - 6. Interpretation of readings of indicating and alarm devices.
  - 7. Protective relay setting considerations.
  - 8. Features, operation and maintenance of separable insulated connector system.
  - 9. Tap-changing procedures.
- B. Schedule training with at least 7 days’ advance notice.

**4. MEASUREMENT AND PAYMENT**

<b>Item</b>	<b>Description</b>	<b>Unit</b>
<b>SS83.20</b>	<b>Distribution Transformer</b>	
(a)	50 KVA, 11/0.4 kV ONAN Transformer.....	Number (no)

The unit of measurement shall be the number of distribution transformers installed.

The tendered rate shall include full compensation for supply, installation, testing, commissioning, putting into satisfactory operation and handing over complete systems of transformers including all compartments and earthing systems required for complete installation.

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## SECTION 8425: MAIN L.V. DISTRIBUTION BOARDS

### 1. GENERAL

#### Related Documents

- A. Drawings and general provisions of Contract, including Project General and Supplementary Conditions, apply to work of this section.
- B. Requirements of the following Electrical Specification sections apply to work specified in this section.
  - 1. Section "Basic Electrical Requirements" & Section "Electrical Testing And Commissioning"
  - 2. "Electrical Specification" Section "BMS" interfacing points

#### Summary

- A. Provide labor, materials, equipment and services, and perform operations required for installation of main low voltage distribution boards and related work as indicated on the drawings and specified herein.
- B. This section includes Main L.V. Distribution Board (MDB) and Sub-Main L.V. Distribution Board (SMDB) work as indicated by drawings and schedules.

Relevance to codes or standards of this Specification.

Work includes mounting frames, fittings, cable termination accessories, gland plates and supports.

- C. Work includes also providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation, power factor correction as shown in accordance with Drawings and Specifications.
- D. Types of MDB's specified in this section are of the dead-front type and include the following:
  - 1. Circuit-breaker MDB's, floor mounted with withdrawable or fixed circuit breaker arrangements equipped with earth leakage module.
- E. Related Sections: the following sections of Division (16) "Electrical Specification" contain requirements that relate to this Section:
  - 1. "LV Circuit Breakers"
  - 2. "Circuit and Motor Disconnects"
  - 3. "LV Wires and Cables"
  - 4. "Earthing"
  - 5. "Electrical Identification"
  - 6. "Transfer Switches"

Refer also to Division (16) "Electrical Specification" Section "Building Management System" for connection to BMS.

#### Submittals

- A. Equipment Data: submit for approval detailed description of main distribution boards with power correction and major components supported by manufacturer's catalogues, indicating compliance with the Standards, equipment characteristics, details of construction, operating data, dimensions and weights etc. Give details of miscellaneous items including incoming and outgoing feeder terminal arrangement, connections at busbars, isolating, earthing, interlocks, control devices, indicating and metering instruments etc.
- B. Tests and Certificates: submit complete certified manufacturer's type and routine test records, in accordance with the Standards. (i.e The switch boards must be totally type tested assembly and complete type test certification to be submitted including S.C, temp. rise, and IP).

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C. Shop and Construction Drawings: submit drawings for approval including, but not limited to, the following;

1. plans and elevations with indication of built-on equipment, exact dimensions and weights of each shipping section, recommended clearances to the front, rear, sides and top, and shipping weights of each draw-out air circuit breaker.
2. arrangement of boards inside rooms allocated, indicating spaces and clearances
3. arrangement of equipment inside board
4. one-line diagram of power system showing current ratings of switchgear and busbars and types and locations of protective gear (relays, instruments, CTs, VTs etc.)
5. schematic and elementary diagrams of control circuits
6. foundation details, grouting holes, installation details
7. arrangement of incoming and outgoing feeders, terminal fittings, instruments, busbar connections etc.
8. detailed shop drawing for power factor correction including three line diagram, control wiring diagram and control operation of the system.

Power factor correction equipment shall be built into a low voltage switchgear assembly as specified in the drawings.

Workshop Drawings shall be provided for each capacitor enclosure and cubicle enclosure. The drawings shall include fully dimensioned external and internal general arrangements showing all principle dimensions, weights, foundation/cable entry details and the positions of control equipment including termination marking.

9. Technical Literature: submit the following for approval prior to placing orders for equipment manufacture:
  - a) Schedule of circuit breaker application, indicating type, range, features and characteristics, short-circuit ratings, time-current curves etc.
  - b) Method of setting of protective devices for overload, short-circuit and earth-fault currents as coordinated with upstream and downstream systems based on specific coordination curves of protective devices used and specific calculated prospective short-circuit currents at various points
  - c) Test methods on site and references.
  - d) Maintenance Data: Submit maintenance data and parts list for each Switchboard (switchgear) including "troubleshooting" maintenance guide. Include that data, product data, and shop drawings in a maintenance manual.
  - e) Instruction manuals with equipment data having sufficient detail for setting relays, timers, capacitors and breakers and time-current curves for breakers and fuses.

### **Spare Parts And Tools**

A. Spare Parts: provide manufacturer's recommended spare parts for emergency replacement and/or one year's maintenance including, but not limited to, the following:

1. One set of fixed and moving contacts for every type of replaceable contact set.
2. One operating motor and/or coil for each type of electrically operated circuit breaker
3. Two sets of each type and rating of indicating light, fuse, LED, control switches, and similar devices subject to failure or breakage at any time.
4. One spare main circuit breaker of each type .
5. One spare feeder of each type furnished.
6. One digital metering and protection module .
7. One circuit breaker trip unit of each type .
8. One dozen each of covers bolts , spring nuts and door fasteners .

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- B. Spare parts shall be boxed or packaged for long term storage and clearly identified on the exterior of package. Identify each item with manufacturers name, description and part number.
  - C. Tools and Instruments: provide tools and instruments required for normal routine inspection and maintenance and testing of circuit breakers and protective devices as appropriate for type of switchgear supplied.

### **Quality Assurance**

- A. Manufacturer's Qualifications: firms regularly engaged in the manufacture of main distribution boards and power factor correction, of types, sizes and capacities required, and whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Contractor's Qualifications: firm with at least 5 years of successful installation experience on projects utilizing switchboard units similar to those required for this project.
- C. Codes and Standards:
  - 1. Standards
    - a) Switchgear, power factor correction and control gear are to comply, as a minimum, with the requirements of, IEC 439-1, IEC 70 A 831 : part 1 and 2, Factory-Built Assemblies of Low Voltage Switchgear , power factor control and Control Gear
    - b) Circuit breakers are to comply with IEC 947-2 and as specified in Section "LV Circuit Breakers".
    - c) Power factor corrections are comply with requirements of applicable local codes, DIN/VDE, IEC, NEC, and standards pertaining to power factor correction.
    - d) Other components, where not otherwise specified, are to comply with the relevant IEC standards.
  - 2. Electrical Regulations/Code Compliance: comply with applicable local regulations/code requirements of the authority having jurisdiction. This will have precedence over other codes/standards nominated for the project, unless otherwise approved in writing.
- D. Factory Testing and Inspection:
  - 1. The manufacturer shall thoroughly test the assembled low voltage switchgear for proper functions and compliance with standards and specifications.
  - 2. Notify the Engineer that the manufacturer intends to carryout factory test The manufacturer shall give the Engineer four weeks written notice . All tests subject to witness by the client or his representative .
  - 3. The manufacturer shall submit full details of the proposed method of testing including connection diagram and time schedule for routine tests.
  - 4. Factory tests shall be carried out in accordance with IEC 439, IEC 70A 831, the Electricity at Work Regulations, the IEE wiring regulations and the documents referenced in each of these publications. Routine tests shall include but not limited to the following:
    - a. Dielectric tests.
    - b. Inspection of wiring and electrical operation.
    - c. Checking of protective earthing.
    - d. Calibration of main circuit breakers releases .
    - e. Testing of all instrumentation and protective relays using primary current injections.
    - f. The following type test certificates shall be presented on switchgear of similar design and construction.
      - Verification of temperature rise limits.
      - Verification of dielectric properties.
      - Verification of short circuit strength.
      - Verification of continuity of protective earthing.
      - Verification of creep age and clearances.
      - Verification of degree of protection.
    - g. Where more onerous requirements are specified herein, the conditions of this specification shall

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- take precedence.
- h. Examine conditions under which power factor correction are to be installed and notify in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

### **Delivery, Storage, And Handling**

- A. Deliver MDB's and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for MDB's and components, which protect equipment from damage. Install gravity measuring meters in containers, which indicates whether container has been bumped or dropped. Return G-meters to manufacturer for reuse upon delivery of MDB's. Inspect equipment to ensure that no damage has occurred during shipment.
- B. Store MDB's 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 MDB's carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

### **Sequencing And Scheduling**

- A. Schedule delivery of MDB and accessories equipment which permits ready building ingress for large equipment components to their designated installation spaces. Coordinate delivery of equipment with the installation of other building components.
- B. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and form work requirements are specified in concrete work.
- C. Coordinate with other electrical work including raceways, electrical boxes and fittings, and cabling/wiring work, as necessary to interface installation of MDB's with other work.

## **2. PRODUCTS**

### **Manufacturers**

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering MDB's which shall be certified as totally type tested may be incorporated in the work include; but are not limited to, the following:
- |                    |                              |
|--------------------|------------------------------|
| Schneider Electric | (France/Korea)               |
| ABB                | (Switzer land/Germany/Korea) |
| Siemens            | (Switzer land/Germany/Korea) |
- Or equally approved
- B. All components used in manufacturing shall be European origin or equally approved. (C.B, C.T's, Relays, .....etc).

### **GENERAL REQUIREMENTS**

- A. Generally: main distribution boards are to be dead- front type, metal enclosed, multi-cubicle, floor mounted, free standing, 1000 V rated insulation voltage and 600 V, rated operational voltage with fixed or draw-out switchgear, manually or manually and electrically operated, as shown on the Drawings, with matching vertical sections to form a continuous integral and rigid structure.
- B. Connection to Building Management System: coordinate with the Building Management System (BMS) supplier and provide all necessary interface devices, dry contacts, relays, transducers, etc, for

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connection of the required points to the BMS as specified or indicated in the BMS schedules. As indicated in (BMS) section in the mechanical specifications

- C. General Construction: rigidly framed and bolted, with electro-galvanized sheet steel enclosures, minimum thickness 1.5 mm, phosphatized, primed with rust inhibiting primer and finished with thermal polymerized polyester epoxy powder coating, grey colour (RAL 7703) to approval. Switchgear is to be vermin, dust and rodent proof, IP 51 protection to IEC 529 for indoor installations, IP55 for outdoor installation, with adequate lifting means and base-frames and capable of being moved into position and directly bolted to floor without additional sills.
- D. Ventilation: compartments are to be ventilated, where required, by approved methods complying with the Standards.
- E. Fastenings between structural members are to be bolted.
- F. Extension of structure and busbars is to be possible at either end of switchboard.
- G. Arrangement is to permit incoming and outgoing busbars and cables to enter enclosure as indicated on the Drawings and connect at respective terminals without inconvenience to installation or maintenance.
- H. Removing Circuit Breakers: Suitable arrangements and equipment are to be provided for extracting, lifting and unloading switchgear from enclosures as appropriate for type of switchgear.
- I. Spare and space positions are defined as follows:
  - Spare position: fully equipped enclosure with switchgear.
  - Space position: fully equipped enclosure ready to receive switchgear.
- J. Busbars: to be site rated for normal current as shown on the Drawings or at least site rated to same rating as main circuit breaker frame size, and braced for a symmetrical rms short-circuit duty equal to or higher than main circuit breaker interrupting duty, for minimum of one second unless otherwise specified or shown on the Drawings. Busbars are to be copper, of sufficient size to limit temperature rise to allowable insulation or equipment temperature ratings, and to a total maximum temperature of 90 deg. C. current density is no more than 1A/1mm<sup>2</sup> Connections and buswork are to be bolted with copper alloy hardware and are to be accessible for inspection and maintenance. Contact surfaces are to be electro-silver plated.
  - 1. The S.C rating of all busbar vertical and horizontal shall be the same value.
  - 2. Busbar support must be non-magnetic support.
  - 3. Busbar shall be edge wise installed.
- K. Connections from busbar to switchgear are to be rated to carry full continuous current rating of switchgear frame and are to be insulated.
- L. Full size neutral is to be continuous through all sections. Neutral bus is to be insulated and separate from earth bus and connected to it with removable links.
- M. Earth bus is to extend full length of board, firmly fixed to each section in accordance with the Regulations and Standards, complete with two main earthing lugs (one at each end), and required number of feeder protective earth connectors.
- N. Switchboard Type: switchboard (s) are to be of the following type (s):
  - 1. Form 4b to IEC 439-1 with metallic separation, is to be front and rear accessible, front and rear aligned with withdrawable main and tie air circuit breaker (ACB) sections (type and rating as shown in the Drawings) and fixed or withdrawable individually mounted outgoing ACB & MCCB distribution section (s). ( type and rating as shown in the Drawings)
- O. Withdrawable metal enclosed circuit breaker section is to consist of compartmented unit(s), stationary part with rear busbar and cable connection compartments and front draw-out circuit breaker assembly. Partitions between sections are to be bolted steel plate and partitions between compartments are to

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be tough solid insulating removable bolted barriers. Each unit is to have hinged lockable front door with grip-handle and door mounted instrumentation.

- P. Drawout circuit breaker assembly is to have disconnecting contacts, wheels and interlocks to prevent connecting or disconnecting circuit breaker unless in the open position, and to prevent closing circuit breaker while racking into any of the three positions (connect, test, disconnect). Racking mechanism and rail assembly are to be approved worm and lever mechanism. It is to be possible to close the unit door with breaker in any of the three positions and when removed. External position indicator is to be provided. Fixed disconnecting primary contacts are to be accessible and replaceable from front and are to be silver plated copper. Moving primary disconnect contacts are to consist of self-aligning, silver plated, spring pressure, finger-cluster copper contacts fitted on line and load studs of circuit breaker.
- Q. Front and rear accessories, front and rear aligned, individually mounted fixed or withdrawable ACB or MCCB distribution sections as basic construction for form 3 and form 4 switchboards, are to be compartmentalised construction, consisting of front modular circuit breaker compartments, busbar system compartments and rear cable termination compartments (as per the form type selected), with insulating barriers between front compartments and busbar compartments and between rear compartments and busbar compartments (removable for maintenance). MCCBs are to be closely coupled to busbars (to minimize chances of bus-side faults), and to rear cable terminals, through compatibly frame-sized insulated connectors. MCCB modules are to be covered on the front, by recessed frame – type bolted covers, 1.5 minimum thickness, to protect circuit breaker handles. Top, sides and rear are to be covered with removable screw-on plates having formed adages all around.
- R. The air circuit breaker (A.C.B) must be equipped with an electronic trip unit using modbus commitment protocol. The air circuit breaker must have main contact wear indicator.
- S. Automatic transfer switches incorporated within switchboards are to be as shown in the drawings and to comply with Section 16495.

### **Circuit Breakers**

- A. Except as otherwise indicated, provide circuit breakers and ancillary components, of types, sizes, ratings and electrical characteristics shown on drawings, which comply with manufacturer's standard design, materials, components, and construction in accordance with published product information, and as required for a complete installation and as approved by the Engineer.
- B. Provide circuit-breakers as specified in Division (16) "Electrical Specification" Section "LV Circuit Breakers", of the following types:
  - 1. Air Circuit Breakers (ACB's); electrically and mechanically operated, 3 or 4 pole as shown on the drawings.
  - 2. Moulded Case Circuit Breakers (MCCB's) meeting with specification of "MCCB's for MDB's.
  - 3. All incoming C.B's for main L.V shall be 4 pole.
  - 4. All circuit breaker above 1000 A must be motorized withdrawable air circuit breakers.
  - 5. All moulded case circuit breakers (MCCB's) must have electronic trip unit.
  - 6. All circuit breakers either air or moulded case must be rated at :  
Ics (service short circuit current) = 100% Icu (ultimate short circuit current).
- C. Provide the following accessories as required on drawings:-
  - 1. electrical operator
  - 2. control and interlocking functions
  - 3. under-voltage release
  - 4. shunt trip coil
  - 5. alarm and auxiliary switches
  - 6. padlocking device
  - 7. key lock device.
- D. Non-fused current-limiting circuit breakers where high interrupting duty is required for small normal current ranges and with accessories as stated above for MCCBs, as shown on drawings.

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## Power Factor Correction Equipments

- A. The power factor correction is required to be automatically controlled by introducing the appropriate number of steps of tuned capacitors bank installed in the distribution board.
- B. Ratings of the capacitor banks are as indicated on the drawings.
- C. The power factor shall be controlled automatically through an electronic power factor regulator.
- D. The regulator shall be capable of controlling the power factor and having an adjustable range 0.8 p.f. inductive to 1.0 setting shall be through knob. It shall be fitted with manual/automatic switch to enable either fully automatic control or manual presetting.
- E. The selectivity of connected capacitors in each regulating step shall be through 3-phase contactors equipped with quick discharging devices.
- F. The admissible overload capacity of the banks shall be in accordance with the technical specifications IEC publ. No. 70, 70 a.
- G. Capacitors shall be of the dry type units, comprising metallic polypropylene self-heating film in the form of a two – film roll, to avoid leaks with pierced tanks and shall be capable of withstanding twice its rated voltage for 10 seconds at rated frequency between terminals. Between terminals and container, capacitor shall withstand 3 KV for 10 seconds.
- H. Capacitor losses shall be less than 0.5 watt/Kvar.
- I. Total losses including accessories as contactors, discharge devices... etc. Shall be less than 1.0 W/KVAR.
- J. The capacitor banks shall be connected to the mains bus bars through fused load break switches. Each fused switch shall be fitted with its HRC fuses with the appropriate current rating according to the capacitor bank rating.
- K. Each distribution board section shall be fitted with a power factor meter with a scale 0.5 capacitive – 1.0 – 0.5 inductive.
- L. It shall be also provided with anti-hunting relay and no-volt protection relay. All auxiliary and control circuits must be protected by fuses or miniature circuit breakers.
- M. Harmonics are taken into account mainly by over sizing capacitors and including harmonic-suppression reactors in series with them.
- N. All series elements, such as connections, fuses, switches, etc., associated with the capacitors are similarly oversized, between 1.3 to 1.5 time's nominal ratings.
- O. Capacitors are linear reactive devices and consequently do not generate harmonics.
- P. It is necessary to ensure that interaction between harmonic – generating devices and power factor correction capacitors, does not result in unacceptable level of voltage and/or current wave – form distortion on the power – supply network distortion on the power – supply network. (i.e. the low – voltage L – C series filters are shunt connected, and are tuned to resonate at harmonic frequencies to which they present practically zero impedance.)
- Q. Design Requirements.
  - 1. Power factor correction shall be applied centrally or locally as specified on the drawings.
  - 2. All power factor correction equipment shall be designed for operation on the nominal voltage and frequency specified in the schedules and shall be capable of operation within the voltage and frequency variations specified in the schedules.
  - 3. All equipment shall be suitable for continuous operation within the ambient air temperature limits and at the altitude specified in the schedules.

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4. Power factor correction equipment shall comprise capacitor units, tuned filters, control relay, switching equipment, protective fuses and means of isolation, all assembled and connected to control automatically the connection and disconnection of the capacitances in response to changes in the load power factor.

R. Capacitors.

1. Capacitors elements shall have a dielectric voltage rating of 480 V 3- phase 50 Hz.
2. Capacitor unit shall comprise a sheet steel enclosure incorporating a number of capacitor elements. The enclosure shall be filled with granules or suitable proven alternative to absorb the energy of any major element failure.
3. Units of equal capacitance shall be interchangeable.
4. Permanently connected discharge resistors shall be provided across the terminations sized to ensure safe discharge of the capacitors to less than 50v within one minute after disconnection.
5. Each capacitor shall be provided with a rating plate giving details specified on the drawing.
6. Each capacitor unit shall comprise a balanced 3- phase system of capacitances.
7. Every capacitor shall be capable of operating for prolonged periods, without damage, at an applied voltage 10% greater than the rated voltage.
8. Every capacitor shall be capable of operating, without damage, under conditions in which the current through it has an r.m.s value exceeding by 15% the current corresponding to the rated (sinusoidal) voltage and frequency.
9. Each capacitor shall be labeled to warn of possible voltage danger.
10. Where capacitor units are to be installed as individual items, not forming part of a factor assembled unit, suitable terminals and terminal box shall be provided to accept the cables specified in the schedule.

S. Assemblies.

1. The complete power factor correction equipment assembly shall comply with all applicable requirements of this specification relating to low voltage switchgear, and shall incorporate adequate provision for connection to the general earth system.
2. The number and capacitance of the capacitor units incorporated in each correction bank shall be such that the capacitance can be switched into and out of circuit in steps as specified in the drawings.
3. Provision shall be made to ensure that a connection point is available for a series connected, de-tuning reactor in case of problems with harmonics.
4. The application of capacitor units shall be automatic via contractors, this process shall be controlled by multi-stage, KV Ar sensitive, solid-state relay, which cycles the capacitor stages so that each is called into service in sequence and advances so that each capacitor is used equally.
5. Where specified, provision to switch all capacitors out of circuit by operation of a remote relay contact shall be incorporated.
6. Switching Contactors shall have a minimum duty category AC4 to IEC, DIN/VDE Standards and a minimum current rating of 1.3 x the current consumed by the capacitor bank.
7. The control relay shall be suitable for operation from the current transformer (s) as specified in the drawings.

T. Enclosures.

1. Each cubicle, and all of the equipment within it, shall be so arranged that every item of apparatus is readily accessible for adjustment, where this may be necessary, and for maintenance.
2. Freestanding Cubicle

Where not forming part of a main LV switchboard, cubicle enclosures shall be constructed of mild steel plate to IEC, DIN/VDE Standards suitable for its location. The enclosure size should allow enough space for at least one additional capacitor unit to be fitted at a later date. The enclosure should have a minimum degree of protection and be finished in the color as specified in the schedules.

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3. Cubicles shall be provided with lifting facilities in the form of pallets for forklift use or fitted with lifting eyebolts.

### **Metering Instruments**

- A. Microprocessor based monitoring device that provide complete electrical metering is to be provided for all the main incoming feeders.
- B. The device is provide reading of the items listed below with the following accuracy:
- |                                    |          |
|------------------------------------|----------|
| current per phase                  | ± 0.5%   |
| Voltage per phase/line             | ± 0.5%   |
| Power                              |          |
| Watts & Watts demand (min. & max.) | ± 1.0%   |
| Vars & Vars demand ( min. &max. )  | ± 1.0%   |
| VA & VA- demand (min. & max. )     | ± 1.0%   |
| Power consumption:                 |          |
| Watt – Hours                       | ± 1.0%   |
| Var - Hours                        | ± 1.0%   |
| Var - Hours                        | ± 1.0%   |
| Power factor                       | ± 2.0%   |
| Frequency                          | ± 1.0 HZ |
- C. The device to be equipped with non- volatile storage of metered data at time of last trip.
- D. The device is to be provided with an addressable communication card capable of transmitting all data over a compatible two-wire local area network to a central personal computer.
- E. The device is to be provided in a draw - out case, which shall permit rapid interchanging of the device with similar unit withdraw requiring panel wiring change. Current transformers secondary shall be automatically short - circuiting contacts shall be visible from the front.
- F. Current and voltage transformer required for the operation of the device are to be provided.
- G. Current transformer (CT): indoor dry type, rated secondary current 5 A. Rated primary current, core size and accuracy are to be determined in accordance with nominal current of plant protected, short - circuit level and burden.
- H. Voltage transformer (VT): to be provided where required, complete with primary and secondary fuses and disconnecting device.

### **Wiring**

- Control wiring shall be minimum 1.5 Sq.mm terminated in terminal blocks, readily accessible in auxiliary compartments. Wiring shall be provided with numbering strips.
- A. Arrangement: wiring is to be modularly and neatly arranged on master terminal boards with suitable numbering strips and appropriate cartridge type fuses where required.
- B. Connections are to be made at front of terminal board and with no live metal exposed.
- C. Metal cases of instruments, control switches, relays etc. are to be connected, by bare copper conductors not less than 2.5 mm<sup>2</sup> section, to nearest earthing bar.
- D. Control Wiring: copper, PVC insulated, 85 deg. C, 600 V grade, and PVC sheathed for multi-core cables. Finely stranded copper conductor, silicon rubber insulated cables are to be used in proximity to higher temperature components and as flexible cable.
- E. Ferrules: wires are to be fitted with numbered ferrules of approved type at each termination.

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## MISCELLANEOUS

- A. Anti-condensation heaters with disconnect switch and pilot lamp are to be provided in switchboard, controlled by thermostat and/or hygostat where this is a requirement by local authorities.
- B. Schematic and wiring diagram is to be provided suitably located within each cubicle.

## ACCESSORIES

- A. Accessories: The following accessories shall be furnished with each switchgear:
  - 1. Two (2) sets of spare indicating lamps.
  - 2. One (1) quart of touchup paint.
  - 3. Portable test kit for testing and calibration of the static logic circuits and the current sensing circuits.
  - 4. One set of special wrenches, removable hand cranks, tools as required to maintain and disassemble parts of the switchgear for field maintenance.
  - 5. Four (4) sets of spare control and instrumentation circuit fuses of each type and size.
- 6. Provide one circuit breaker transport trolley for each electrical room containing switchgear.

## Secondary Metal Clad Tie Bus

- A. Where specified or indicated on the drawings provide an overhead totally enclosed, low impedance, feeder tie bus duct between low voltage switchgears as shown on drawings or as specified. Bus duct shall include necessary fittings, hangers and accessories.
- B. Bus duct shall be in accordance with IEC standards.
- C. Bus duct shall be three phase, four wire with internal ground bus. Voltage and continuous current rating shall be indicated on drawings or as specified. Bus duct shall be suitable for mounting in any position without derating. Unless otherwise indicated, provide ground bus with minimum rating of 25 percent of the phase busses and neutral bus rated 100 percent.
- D. Housing shall be fabricated of galvanized sheet steel with hardware plated to prevent corrosion. Finish shall be ANSI No. 61 for indoor units and ANSI No. 24 for outdoor units.
- E. Joints shall be of the one bolt type with through-bolts permitting checking for tightness without de-energizing the bus duct.
- F. Bus bars shall be fabricated from 98 percent conductive copper and plated at contact surfaces and joints. Plating shall be silver. Busbars shall be insulated over their entire lengths. Temperature rise shall not exceed 55 degrees C over a 50 degree C ambient when carrying full load and in any position. Short circuit bracing shall be as indicated with minimum rating of 50 KA amperes RMS.
- G. Final measurements shall be made by the Contractor prior to release for fabrication.

## 3. EXECUTION

### Examination

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

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### **Preparation**

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this Section.
- B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this Section with the work of related trades, to avoid delays.
- C. Provide templates as required to related trade for location of items.

### **Installation Of Switchboards**

- A. Install switchboards as indicated, in accordance with manufacturer's written instructions, and with recognized industry practices; complying with applicable requirements of applicable standards or codes approved.
- B. Equipment Bases: ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.
- C. Built-In Items: ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.
- D. Equipment: install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.
- E. Supports and Terminations: install all incoming and outgoing cable supports, cable ends and termination fittings required for power and control cables.
- F. Relays: set in accordance with manufacturer's instructions and in accordance with an approved scheme.
- G. Make good damaged painted surfaces, clean and apply rust-inhibiting prime coat and two finishing coats of approved enamel upon delivery of equipment to site, or as required by the Engineer.
- H. 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 applicable standards.
- I. Grounding: All switchgear compartments shall be bonded to the main ground bus . Protective and instrument cases shall be bonded . Bond all switchgear doors with flexible earthing strap , green yellow insulated .
- J. Install switchgear on vibration isolators in accordance with manufacturer's requirements.
- K. Set, adjust and calibrate protective devices in accordance with the approved coordination study.
- L. Provide housekeeping pad under switchgear as specified in Section (16010).
- M. Provide the services of the manufacturer's qualified service engineer, at the job site, for as many days as required, to provide guidance to the Contractor during installation, to inspect for proper installation, perform debugging, check and make adjustments for proper operation of the devices and equipment, set protective devices, test and calibrate protective devices in the field with secondary current injection and instruct the Owner's designated personnel in the care and operation of the equipment.
- N. Install power factor correction equipments as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards, and in accordance with recognized industry practices to ensure that installation complies with recognized industry practices to ensure that installation complies with requirements and serves intended function. Coordinate, as necessary to interface installation of power factor correction.

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- O. Provide fuses in control and instrumentation sections as required. Provide 3 spare fuses of each size and type

### **Field Quality Control**

- A. Equipment: inspect equipment upon delivery to Site and report any damage to the Engineer.
- B. Switchgear: inspect and check switchgear for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.
- C. Tests: after installation and before handover, carry out all tests required by the governing codes and any other tests the Engineer may require to check compliance of installation with the Specification, including insulation resistance tests and operational tests. Routine works tests shall be carried out in the presence of the Engineer.
- D. Main and Control Circuits: using 1000 V megger (2000 Megohm range), check insulation resistance between phases, between phases and earth/enclosure and between neutral and earth.
- E. Primary Injection Tests: provide 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.
- F. Instantaneous Trip Elements: test by high current primary injection, using high- current primary injection test- sets and report all readings.
- G. Routine tests on site are to be carried out on every main distribution board in accordance with the Standard specified (IEC 439 or BS 5486: Part 1) for FBAs assembled from standardized components outside the works of the manufacturer. Routine tests are also to be carried out on every FBA, delivered to site, if requested by the Engineer.
- H. Prior to energization of switchboards and circuitry, check all accessible connections to manufacturer's torque tightening specifications.
- I. Prior to energization of switchboards, check with ground resistance tester phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.
- J. Prior to energization, check switchboards for electrical continuity of circuits, and for short-circuits.
- K. The manufacturer shall provide additions, modifications or replacements necessary to provide the Owner with a unit which fully conforms to the Specifications.
- L. Prior to energization of power factor correction equipment, test equipment for continuity of circuitry and for short circuits. Replace malfunctioning equipment for continuity of circuitry and for short circuits. Replace malfunctioning equipments with new equipments and then demonstrate compliance with requirements.

### **Adjusting and Cleaning**

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

### **Earthing**

- A. Provide equipment earthing connections for switchboards as indicated. Tighten connections to comply with tightening torque's specified in applicable standards to assure permanent and effective earthing.

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**Demonstration**

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

**4. MEASUREMENT AND PAYMENT**

<b>Item</b>	<b>Description</b>	<b>Unit</b>
<b>SS84.25</b>	<b>Main L.V. Distribution Boards</b>	
(a)	150A 4P MCCB Incomer and 9 Outgoing specified MCCBs Outdoor type Main Distribution Board of IP 65 c/w contactor controlled by a photocell for street lighting, and traffic light and outdoor lights.....	Number (no)

The unit of measurement shall be the number of main L.V. distribution boards installed.

The tendered rate shall include full compensation for supply, installation, testing, commissioning, putting into satisfactory operation and handing over complete systems of main L.V. distribution boards including all necessary accessories and internal connections, circuit breakers and copper busbars required for complete installation.

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## SECTION 8452: EARTHING

### 1. GENERAL

#### Related Documents

- A. Drawings and general provisions of Contract, including Project General and Supplementary Conditions and Division (1) Specification Sections, apply to work of this section.
- B. Requirements of the following Division (16) "Electrical Specification" Sections apply to this Section:
  - 1. "Basic Electrical Requirements."
  - 2. "Electrical Testing And Commissioning"

#### Summary

- A. Provide labor, materials, equipment and services and perform operations required for installation of Earthing System and related work as indicated on the drawings or specified herein.
- B. 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. Transformer neutral earthing
  - 2. Main earthing terminals or bars
  - 3. Exposed conductive parts of electrical equipment
  - 4. Extraneous conductive parts
  - 5. Standby generator neutral earthing.
  - 6. Un-interruptible power supply system.
  - 7. Electronic and light current systems.
- C. Related Sections: the following sections contain special requirements that relate to this section:
  - 1. Division (16) "Special Construction" for "Light Current Systems" earthing
  - 2. Division (14) "Conveying Systems"
  - 3. Division (15) "Mechanical Work" for "Mechanical Equipment & Installation"
  - 4. Division (16) "Electrical Work" for "L.V Wires and Cables" for earthing system.
  - 5. Division (16) "Electrical Work" for "Lightning Protection System".

#### 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

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- 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.

### **Submittals**

- A. General: submit the following in accordance with Conditions of Contract General Requirements and Specification Sections.
- 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 panelboards 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.
- H. 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.

### **Quality Assurance**

- A. Regulations and Standards: carry out work in accordance with the following:
1. IEC publications 364-3 and 364-4-41, Electrical Installations in Buildings
  2. BS7671:1992 Requirements for Electrical Installations. (IEE Wiring Regulations).
  3. BS 7430 Earthing
  4. IEEE 80, 1986, IEEE90

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- 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.
  - C. In case of deviation of the applicable standards the most stringent shall be applied.

## 2. PRODUCTS

### Manufacturers

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering grounding and bonding products which may be incorporated in the work include, but are not limited to, the following:

Furse, W.J and Co. (England)

A.N. Wallis (England)

Or other equal and approved manufacture of 15 years minimum experience.

### 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 earthing pits for each system as shown on the drawings, which is buried around the perimeter of the building at 1 m (min.) below the finish grade level and 0.6 m away from the building. Scope of work starts from the main earth conductors connecting between the earth electrodes and the earth busbars and is to include all earthing and bonding installation of the project as specified and shown on the drawings.
- C. Overall resistance to earth of the earth electrode is not to exceed 2 ohms (for power applications) measured in summer. Additional earth rods connecting with the earth electrodes 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:
  - cast iron pipes with special surround material
  - copper plate (s)
  - 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 as shown on the Drawings
- 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 Table 54G of IEE Regulations.

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- 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 over-current 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 1 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 6 mm<sup>2</sup>.
- 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 mm<sup>2</sup>.
- M. Identification: connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labeled 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'.

### **Materials and Products**

- A. Earth Rod: copper clad steel, 19 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. 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'.
- C. Main Earthing Conductors from Earth Electrode to Main Earthing Bars: annealed tinned copper bars, 60X4mm<sup>2</sup> as shown on the Drawings.
- D. Earthing Conductors: insulated or bare copper conductor as described in the Specification for the particular application or shown on the drawings
- E. 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.
- F. 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.
- G. 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.

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- H. 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.
  - I. Equipotential/Signal Reference Earthing Bar: hard drawn copper, tinned copper bars 60 x 4 mm, drilled for connection of conductor every 50 mm and to be supplied with copper alloy bolts, nuts, washers and wall mounting insulators for installation in mechanical rooms and low current rooms. Equipotential earthing bar for small mechanical rooms is to be 25 x 3 mm hard drawn copper.
  - J. Bonding of main and signal reference earthing bars and earthing conductors to the building structure rebars is to be through 70 mm<sup>2</sup> copper conductors connected to the rebars via exothermic welding as shown on the drawings.

### 3. EXECUTION

#### Transformer Substation Earthing

- A. MV Switchgear: internal earth bar of the switchgear is to be connected to the room's main earthing bar by two insulated earthing conductors, one at each end of bar, via testing joints. Earthing conductor is to be minimum 150 mm<sup>2</sup>.
- B. LV Switchgear (main distribution board): internal earth bar of the switchgear is to be connected to the room's main earthing bar at two extreme ends by two insulated earthing conductors through testing joints. Earthing conductor size is to be minimum 240 mm<sup>2</sup>.
- C. Transformer earthing terminal is to be connected to the room's main earthing bar by insulated copper earthing conductor not less than 150
- D. Transformer neutral (Star Point) is to be connected by insulated earthing conductor (colour black) to the room's main earthing bar. Neutral earthing conductor is to be sized for maximum earth fault current for 5 seconds with final conductor temperature not exceeding 250 deg. C, but not less than 240 mm<sup>2</sup>

#### Earthing Of Distribution Boards, Panelboards, Lighting Installations and Wiring Accessories

- A. Distribution, lighting and power panelboards are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panelboards 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 panelboards.

#### Generator Plant Earthing

- A. Generator neutral (Star Point) is to be connected by insulated earthing conductor through the neutral earthing link or device to main earthing bar. Neutral earthing conductor is to be suitably sized to carry maximum earth fault current for time it takes the system protection to operate with final conductor temperature not exceeding 250 deg. C, but not less than 240 mm<sup>2</sup>
- B. Generator earthing terminal is to be connected to main earthing bar by insulated copper conductor of cross section not less than 120 mm<sup>2</sup>
- C. Switchgear and Control Gear: earthing terminals or bars of switchgear and control gear are to be connected by separate protective conductors to respective normal and emergency main distribution board earth bars.

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- D. Extraneous conductive parts including steel frames, battery racks, day-tank, pumps and piping are to be connected by bare copper earthing conductors to main earth bar in compliance with bonding regulations.

### **Mechanical Plant Rooms and Fixed Machinery**

Equipotential earthing bar is to be conveniently located in mechanical rooms, 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. 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.

- A. 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 (or 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.
- B. 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.

### **Electronic and Communication Equipment Rooms**

- A. Separate earth bar is to be provided in each electronic and communication equipment room for signal reference earthing of equipment as shown on the drawings.
- B. Signal reference earth bar is to be connected to the earth electrodes of communications and bonded to the building steel rebars as shown on the drawings.
- C. Overall resistance to earth of the earth electrode is not to exceed 0.5 ohms (for light current applications) 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.

### **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.
- J. All non Electrical Metal in the plant rooms shall be earthed by copper wire, bare type 35 mm<sup>2</sup>.
- K. Earthing Conductor of transformers, Generators, Motors and mechanical plant room equipment's (chillers, A,H.V,...)....etc are to be connected to the protective earth system through 150 mm<sup>2</sup> insulated copper conductor in two diagonal points on the equipment frame.

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### 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.

#### 4. MEASUREMENT AND PAYMENT

<b>Item</b>	<b>Description</b>	<b>Unit</b>
<b>SS84.52</b>	<b>Earthing</b>	
(a)	Earthing the entire substation.....	Number (no)
(b)	Earthing the entire DBs.....	Number (no)

The unit of measurement shall be a Lump Sum for the earthing system installed.

The tendered rate shall include full compensation for supply, installation, testing, commissioning, putting into satisfactory operation and handing over complete earthing system.

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## SECTION 8470: PANELBOARDS

### 1. GENERAL

#### Related Documents

- A. Drawings and general provisions of Contract, including Project General and Supplementary Conditions, apply to work of this section.
- B. Division (16) "Basic Electrical Requirements", "Electrical Testing And Commissioning" and other sections apply to work specified in this section.
- C. Division (16) "Electrical Specification", Section "Building Management System".

#### Summary

- A. Provide labor, materials, equipment and services, and perform operations required for installation of panel boards and related work as indicated on the drawings and specified herein.
- B. This section includes panelboards 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.
- C. Types of panelboards and enclosures required for the project include the following:
  - LCP :Final branch circuit Lighting Control Panelboard (Dimmable Panel).
  - LPB : Final branch circuit Lighting panelboard.
  - DB : Distribution panelboard (for normal power system).
  - MCC : Distribution panelboard (for mechanical equipment system).
  - Note 1 : Final branch circuit lighting panelboards, and power panelboards for secondary lighting and power distribution are designated with either miniature circuit breaker (MCB) or moulded case circuit breaker (MCCB) protection on subfeeder or branch circuits, as shown on the drawings.
  - Note 2 : Panel boards supplied from U.P.S source are with the letter (UPS).
  - Note 3 : Panel boards supplied from emergency source are prefixed with the letter E.
- D. Refer to other Division (16) "Electrical Specification" section "L.V Wires and Cables", Section "Electrical Cabinets, Boxes and Fittings", and Section "Raceways" required in conjunction with installation of panelboards and enclosures.
- E. Refer to Division (16) "Electrical Specification" section "L.V Circuit Breakers" for circuit breaker applications and recommended types and frames for this project.
- F. Refer to Division (16) "Electrical Specification" section "Building Management System" for connection to BMS.

#### Submittals

- A. Product Data: submit manufacturer's data and catalogues on panelboards and enclosures.
- B. Dimensions and contents of each panelboard.
- C. Coordinated tabulations of series short circuit combination of circuit breakers.
- D. Wiring Diagrams: submit wiring diagrams for panelboards 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.
- G. Shop drawings : submit drawing for approval including but not limited to the following :

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1. Exact composition of each panel board , bus bar rating , frame or continuous rating and trip rating of circuit breakers .
  2. Dimensional drawings and installation details to the manufacturer's recommendations , indicating main feeder and branch circuit conduit connections , terminal provisions , rags & cable .

### **Quality Assurance**

- A. Manufacturer's Qualifications: firms regularly engaged in manufacture of panelboards 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 panelboards similar to those required for this project.
- C. Codes and Standards:
  1. IEC 439, Factory Built Assemblies of Low Voltage Switchgear and Control gear or equal international standards.
  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 panelboards and enclosures in this project.
  3. Incoming and outgoing circuit breakers shall comply with IEC 947-2.

### **Sequencing And Scheduling**

- A. Coordinate installation of panelboards and enclosures with civil/archite-ctural program and installation of wires/cables, electrical boxes and fittings, and raceway work.

### **Electrical Closets**

- A. Spaces for electrical closets indicated in the drawings are maximum . Check clearances , spaces and ventilation for the installations of proposed equipment layout prior to selection of the equipment and verify space availability

## **2. PRODUCTS**

### **Manufacturers**

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering electrical panelboard with European made components which may be incorporated in the work include, but are not limited to, the following:

1. Panel Boards

Schneider Electric	(France/Korea)
ABB	(Switzerland/Germany/Korea)
Siemens	(Switzerland/Germany/Korea)
Or equally approved.	

### **Panelboards - General**

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

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- A. 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 529 and are to be factory designed and assembled. Panelboard switching and Protective devices, quantities, size, rating, types and arrangement as shown. Select unit with feeders connecting at top or bottom of panel as indicated or required.
  - C. Earthing bar is to be provided in every panelboard and to be half size the phase busbars.
  - D. Neutral bar is to be provided in every panelboard and to be full size as per the phase bus bars.
  - E. Protection is to be fully rated though-out the systems.
  - F. Circuit breakers are to be non-fused type.
  - G. Circuit breaker arrangement: panelboards 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 panelboards are to be designed for sequence phase connection of branch circuit devices.
  - H. Branch circuit numbering: on 3-phase panelboard 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.
  - I. 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.
  - J. Series (cascade) coordination protection (integrated equipment short circuit ratings) where indicated coordination between the series circuit breakers (main and branch) shall be in accordance with IEC standards and with an integrated series combination chart prepared by the manufacturer, tested and certified in the country of origin by an internationally authorized organization, where short circuit ratings are beyond available fully rated types specified, and with the approval of the Engineer .
  - K. Short circuit rating shall be more than the calculated level at point of utilization unless indicated on the drawings.
  - L. Panel boards shall be the product of one manufacturer unless otherwise approved by the Engineer.
  - M. Where main bus rating is , not shown on the drawings , it shall be rated not less than the setting of the feeder over current device .
  - N. Pre-drilled neutral and earthing bars are fitted as standard to save installation.
  - O. All moulded case circuit breakers must have electronic trip unit
  - P. All circuit breakers must be rated at:
  - Q.  $I_{cs}$  (service short circuit current) = 100%  $I_{cu}$  (ultimate short circuit current).

### **Panelboard 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 predesigned angles or threaded end studs to support and adjust mounting of interior panelboard 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 panelboards are to overlap box and front shields by at least 20 mm. Trims for surface mounted panelboards 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

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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 glassine 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 panelboards 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.
- H. Directories : Provide interior circuit directory frame for wire and cable color code ident for each voltage system with clear plastic covering .
- I. Provide sufficient space for terminating cables entering and leaving the panel in accordance with cable schedules .
- J. Provide instruments kit where indicated or shown on the drawings .

### **Busbars**

- A. Type: one piece, 98% pure electrolytic copper, based on a total maximum operating temperature of 90 deg. C at full continuous rating (50 deg.C temperature rise above 35 deg.C ambient). Bolted or clamped contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminum is not to be used for busbars or panelboard parts.
- B. Design: busbars 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 panelboard 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.
- H. Busbar support must be non-magnetic metallic support and also shall be edge wise installed.

### **Distribution Panelboards (DB) & (MCC)**

- A. DB: to have a rated insulation voltage of 1000 V, rated operational voltage of 400 a.c. or d.c., and to be conforming to IEC 439: Part 1, Form 3a, floor or wall surface mounted, suitable for ratings of main breaker or switch and busbars 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.

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- D. Interior of panelboard is to be pan assembly consisting of galvanized sheet steel chassis minimum 2 mm thick, folded, flanged and reinforced, with busbars 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.

#### **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.

#### **Final Branch Circuit, And Power Panelboards - Type MCCB**

- A. Type: to have a rated insulation of 1000 V and rated operation Voltage of 400 V a.c. and 240 V d.c., lighting and distribution type (lighting and appliance type, to N.E.C.), 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 frame size, as shown in the drawings with trip ratings between 15 A and 100 A, and compatible ICs, selected from normal (N), high-break (H) or current-limiting (L) range, as indicated in section "LV Circuit Breakers" of this specification.
- C. Assembly: bus bars 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.

#### **Final Branch Circuit Panelboards - Type MCB**

- A. Type: to have a rated insulation voltage of 1000 V and a rated operational voltage of 400 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 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. Panelboards are to comply with BS 5486 Part 12.
- C. SPN type panelboards are to be, single-phase and neutral, with MCBs on branch circuits and MCS main incoming (or as shown on the drawings).
- D. Single pole and double pole MCBs, are to have trip ratings between 16A and 50A, with ICs as required in the Schedules.
- E. TPN type panelboards 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 16 A and 100A, with IC as required in the Schedules.
- G. TPN type panelboard 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.

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### **Final Branch Circuit Panelboards; Split-Bus MCCB/MCB Types**

- A. Assembly is to be as specified for MCB or MCCB type of branch circuit panelboard, but with split-bus arrangement, part of which is controlled by in- built submain contactor or circuit-protective device for group control of a number of branch circuits. Panelboard is to have main circuitbreaker for protection and isolation.
- B. Contactors: provide 2 or 3-pole, Electro-magnetic type, class AC 5b or AC5a to IEC 947-4, 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.

### **Residual Current Devices**

- A. For earth leakage protective circuit breakers are to be add - on devices , or built in and integral with standard circuit breaker .

### **Auxiliaries**

- A. Where required or shown on the drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage release, motorized mechanism or similar units, which are to be modular additions to the circuit breakers.

## **3. EXECUTION**

### **Examination**

- A. Examine areas and conditions under which panelboards 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.

### **Preparation**

- A. Examine the Contract Drawings and specifications in order to insure the completeness of the work required under this Section.
- B. Verify measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this Section with the work of related trades so as not to delay job progress.
- C. Provide templates as required to related trade for location of items.

### **Installation of Panelboards**

- A. Install panelboards 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 fulfill requirements.
- B. Align, level and securely fasten panelboards to structure, ensuring that they are permanently and mechanically anchored.
- C. Fix surface mounted outdoor panelboards at least 25 mm from wall ensuring supporting members do not prevent flow of air.
- D. Do not use connecting conduits to support panelboards.
- E. Close unused openings in panelboard cabinets.
- F. Do not install interior of panelboards in cabinets until all conduit connections to cabinet have been completed.
- G. Wiring inside panelboards 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 (install trims in final position prier to finish painting).
- 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 panelboard's circuit directory card upon completion of installation work in a proper and neat manner acceptable to the Engineer.

**Earthing**

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

**field quality control**

- A. Prior to energization of electrical circuitry, with C.B in open position, check all accessible connections to manufacturer's tightening torque specifications.
- B. Prior to energization of panelboards, with C.B in open position, 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 1000V megger for equipment on systems up to 400V for 1 minute with CBs in open position.
- C. Prior to energization, with C.B in open position, check panelboards 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) "Electrical Specification" 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 panelboards assembled from standardized components of the manufacturer outside the works of the manufacturer.

**Adjusting and Cleaning**

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

**Demonstration**

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

**4. MEASUREMENT AND PAYMENT**

<b>Item</b>	<b>Description</b>	<b>Unit</b>
<b>SS84.70</b>	<b>Panel Board</b>	
(a)	Sub DB 3 for bridge lighting as specified.....	Number (no)
(b)	Sub DB 4 for traffic lighting as specified.....	Number (no)
(c)	Sub DB 5 traffic lighting as specified.....	Number (no)
(d)	Sub DB 6 traffic lighting as specified.....	Number (no)
(e)	Construction of Plinth for DBs.....	Number (no)
(f)	Prefabricated LxWxH of 1x0.75x1.5 Panel for hosting CCTV active control equipment at the Bridge, c/w cooling dual fans and regulator with alternate control timer switchings.....	Number (no)

The unit of measurement shall be the number of panel boards installed.

The tendered rate shall include full compensation for supply, installation, testing, commissioning, putting into satisfactory operation and handing over complete systems of outdoor type panel board including all necessary accessories and internal connections, circuit breakers and copper busbars required for complete installation.

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The tendered rate for construction of plinths shall include full compendation for procuring, transporting, installation, testing, and commissioning of all materials required for the construction of the plinths.

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## SECTION 8520: EXTERIOR LIGHTING

### 1. GENERAL

#### Work Included

- A. Description: Furnish, install, connect and test the following, all as shown on the drawings and specified herein:
  - 1. Street lighting poles, luminaries, fittings and accessories.
  - 2. Free standing bollards and luminaries.
  - 3. Wall mounted exterior light fittings and luminaries.
- B. Related Work Specified Elsewhere:
  - 1. Section of Quality Control
  - 2. Section of Concrete Reinforcement
  - 3. Section of Precast Structural Concrete
  - 4. Section of Painting
  - 5. Section of General Provisions for Electrical Work
  - 6. Section of Basic Materials and Methods
  - 7. Section of Power System Warning Signs and cable Identification.
  - 8. Section of Conductors and Accessories
  - 9. Section of Grounding and Bonding
  - 10. Section of Lighting Fixtures

#### Applicable Codes and Standards

The following codes and standards are intended to provide an acceptable level of quality for materials and products. The Contractor may propose alternative codes and standards providing them giving an equivalent degree of quality as the referenced codes standards and are submitted to the owner consultant engineer for reviewing and approval in advance of their use. All equipment furnished under these specifications which is not determined or having any restrictions in local regulations concerning with electrical affairs shall conform to the appropriate standards of:

- 1. NEC                      National Electrical Code
- 2. NEMA                    National Electrical Manufacturers Association
- 3. IES                        Illuminating Engineering Society
- 4. ANSI                     American National Standards Institute
- 5. ASTM                    American Society for Testing and Materials
- 6. NFPA                    National fire Protection Association.

#### Submittals

- A. The following shall be submitted to the owner consultant engineer for approval prior to commencing work:
  - 1. A list identifying manufacturers and all material and equipment items proposed for use in the work of this Section.
  - 2. Manufacturers' specifications, data sheets, shop drawings, installation instructions, operation instructions, and maintenance and repair recommendations for each item.
  - 3. Manufacturers' Certificates of Compliance: To indicate that each material and equipment item

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complies with the requirements of the specifications. Any test results shall also be submitted, in report form.

4. Recommended list of spare parts.

### **Product Delivery, Storage And Handling**

- A. All fittings, panels, luminaries and accessories shall be boxed, crated, and wrapped, or otherwise suitably protected during delivery, storage and handling. On delivery, they shall be stored in a secure and dry facility.
- B. All poles shall be suitably packed during transportation and protected from abrasion, impact and other damage.

### **Spare Parts**

- A. The Contractor shall not use any spare parts furnished under the contract with the equipment, without the owner consultant engineer approval. These shall be stored as directed by the owner consultant engineer.

### **Quality Control**

- A. The Contractor shall be responsible for the quality of all materials used in the work in accordance with section of quality control. The Contractor shall develop a supplier quality control program for review covering procedures for shop inspection and field supervision to ensure acceptability of materials, fabrication, welding, galvanizing, and installation.

## **2. PRODUCTS**

### **GENERAL**

- A. All goods and products covered by these specifications shall be procured, when available, from an approved manufacturer. Procurement of all goods and products shall be approved by the owner consultant engineer.
- B. All goods and products shall be new and designed for operation in a corrosive atmosphere at 2300 m above sea level, an ambient temperature of 40 °C and humidity of 90%.

### **CRITERIA FOR MID HINGED LIGHTING POLE ASSEMBLIES**

These criteria apply to aluminum, steel and fiber- glass lighting pole, bollards, & arm assemblies.

- A. Poles and mast arms shall be designed and fabricated for service under the following conditions:

Wind Speed	180 km/hr
Temperature range	-5 C° to 50 C°
Relative humidity range	10% to 100%

- B. All elements of lighting pole assemblies shall be designed and fabricated to preclude the entry of water.
- C. Smooth raceways shall be provided inside all elements for internal wiring.
- D. All materials shall be anti- corrosive type.

### **Aluminum Poles & Arms**

- A. Poles
  1. Poles shall be one-piece seamless tapered tubes fabricated by anti-corrosive material Poles shall have full-length tapers with round or polygonal cross sections.
  2. Each pole shall be provided with a reinforced oval handhole, minimum size of 100mm x 165mm,

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located on the side away from traffic. Wrought aluminum covers conforming to ASTM B 26 and stainless steel tamper proof screws for attaching covers to handhole shall be provided.

3. Each pole shall be provided with a copper alloy grounding lug, readily accessible from the handhole.
4. Each pole shall be provided with a removable cast aluminum pole cap, held securely in place.

**B. Arms:**

1. Arms shall be single member or truss-type as indicated per drawings and shall be made of aluminum alloy conforming to ASTM anti-corrosive type and shall have a suitable mechanical strength.
2. Provisions shall be made for bolting either a single member or truss-type mast arms to poles. Wrought aluminum bolting plates aluminum alloy, shall be welded to poles; matching plates shall be welded to arms.
3. Bolts and nuts, or tube nuts, shall be of .type 304 stainless steel material conforming to ASTM - A 276.

**C. Anchor Base**

1. The anchor base shall be die cast anti corrosive aluminum, conforming to the requirements of ASTM B 85. The aluminum alloy shall be selected to give minimum yield strength of 290 MPa. The base shall telescope the pole and shall be welded to the pole by two circumferential welds, one on the inside bottom and one on the outside top. The base shall be designed and welded to develop the full strength of the pole.

**D. Welding of Aluminum**

1. All welding shall be performed by welders who have provided certifications that they are fully qualified in the welding of aluminum. Certifications shall be acceptable to the owner consultant.
2. The inert gas shield arc method shall be used. Welds shall be free from cracks and porosity.

**E. Hardware**

1. All mounting and fastening hardware use in conjunction with aluminum poles and arms shall be of type 304 stainless steel material conforming to ASTN A 276.

**F. Finish**

1. Aluminum poles and mast arms shall be finished with a uniform non specular surface, the natural colour of Aluminum. Anodizing shall be applied to the aluminum for surface protection and long life. Surfaces shall be anodized to form an oxide film of not less than 22 micron, after which a proper sealing process is required. Finish shall be smooth, uniform and free from disfiguring scratches, dents and other detrimental markings.

**Steel Poles & Arms**

**A. Poles**

1. Poles shall be tapered galvanized steel anti- corrosive type tubes fabricated from minimum 3mm thick steel conforming to specification ASTN A595 or A36. The pole shall be tapered uniformly for its full length. One longitudinal electric arc weld will be permitted; no transverse welds will be permitted. After welding, the pole shall be cold rolled to flatten the weld. And to develop a minimum yield strength of 330 Mpa. Poles shall have round or polygonal cross sections.
2. Each pole shall be provided with a reinforced oval handhole, minimum size of 100mm x 165mm, located on the side away from traffic.

**FIBERGLASS POLES AND ARMS**

**A. Poles**

1. Poles shall be of fiberglass reinforced polyester (FRP), cylindrical or conical. The pole surface shall be totally weather and corrosion resistant in earth and air, completely smooth exterior,

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homogenous and non-porous. No glass fibers shall appear at the outer surface, and the outer 0.5-1.0mm shall consist of pure polyester. A minimum of one layer of the fiberglass-reinforced polyester shall be unidirectional. The poles shall be available in any colour specified by the owner consultant the colour shall be completely light stabilized and impregnated from the surface through the thickness of the material.

2. Mast Pole tops shall be designed to receive the approved arm(s) and/or luminaire (s).

The pole tops and the parts of the pole surface intended as assembly attachment points for further accessories shall be reinforced with stainless steel wire mesh to prevent loosening of fasteners in those particular areas.

3. Each lighting pole shall have a handhole access, fully integrated into the surface of the pole. The handhole door shall be weatherproof, electrically safe and tamper proof.

#### B. Arms

1. Mast arms shall be of galvanized steel, anodized aluminum or other compatible corrosion resistant material, of length indicated in contract drawings.

#### C. Anchor Base

1. Pole base shall be a steel plate, which forms an integrated part of the pole. The pole base shall have a welded vertical steel inner cone, which extends into the bottom of the fiber-glass pole.
2. The steel plates shall conform to ASTM A-36 or approved equal. The steel base plate shall be complete with holes pattern, as shown in the drawings, for high tensile strength anchor bolts and one central hole for cable entry.

#### D. Accessories

1. All steel accessories of the pole shall be hot dipped galvanized conforming to ASTM A-123 or approved equal after completion of the fabrication. No further touching up, finishing or modifications shall be carried out after galvanizing. The minimum thickness of zinc coating shall be 500 g/sq.m. The galvanizing shall be carried out by total immersion in a bath of molten zinc.

### **ANCHORS BOLTS**

- A. Anchor bolts shall be made from high strength steel having minimum yield strength of 345 MPa. The treaded portion shall be 150mm long. Other dimensions shall be as shown on the drawings. Two hexagon nuts shall be furnished with each bolt; one for leveling and one for fastening. The threads of the bolts and the hexagon nuts shall be hot-dipped galvanized in accordance with ASTM A 153.

### **SLIP BASE INSERTS**

- A. Poles shall be fitted with slip base inserts when so indicated on the drawings.
- B. The plates comprising the slip base insert shall be steel conforming to the requirements of ASTM A 36. Alternatively, the bottom plate may be cast steel, conforming to the requirements of ASTM A 27, Grade 70-40.
- C. The steel plates shall be galvanized to ASTM A 123.
- D. For poles with steel bases, nuts and bolts in slip base inserts shall be steel conforming to ASTM A 325, galvanized to ASTM A 153; or alternatively, Type 304 stainless steel material conforming to ASTM A 276.
- E. For poles with aluminum bases, nuts and bolts in slip base inserts shall be stainless steel.

### **BOLLARDS**

- A. Bollards shall be manufactured to the dimensions shown, and the fasteners shall be of the sizes shown, in the Contract Drawings. The bollard shaft shall be constructed of heavy gauge, thick wall anti-corrosive alloy of aluminum in one seamless tube. The top cap shall be cast aluminum sealed against the weather and secured with a socket, tamper-proof screw. The internal cast aluminum base plate shall be secured with four (4) anchor bolts on a bolt-circle. The polished-diffuser shall be polycarbonate and be enclosed

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by. Polycarbonate or aluminum louvers set at a 45 angle. The alignment rods shall be cadmium-plated steel and the lamp holder shall be weather-proof ceramic designed for firm lamp support.

- B. The all aluminum construction architectural surface shall be finished with non lead black baked acrylic enamel or other selected finish. Painting shall be as specified in Section of painting.
- C. Outside dimensions and construction shall be in accordance with the detailed Contract Drawings.

## LUMINAIRES

- A. General: Luminaires and all accessories shall comply with the requirements specified below: and the luminaires shall be suitable for operation on 220V, 50Hz. unless shown otherwise on the drawings.

Ballast shall conform with applicable requirements of ANSI C82-4 it should be thermally protected, high power factor auto-regulator type with a minimum operating power factor of 95%, Ballasts shall be suitable for operation within  $\pm 10$  percent variation in voltage, and  $\pm 2$  percent variation in lamp watts Luminaires shall be equally distributed on 3 phase Luminaires type are specified in the following paragraphs:

- B. Luminaires Types – Pole Mounted

1. Mounting height as per DWG: The luminaire shall house 162 watt LED lamp and shall have a one-piece die-cast aluminum – silicon alloy body to give maximum resistance to corrosion. The control gear shall be integral within a separate compartment of the luminaire housing. A porcelain lampholder shall be supplied with a terminal block of non-hygroscopic material. The refractor of the luminaires shall be prismatic heat resistant borosilicate glass, the prismatic formation to redirect the lamp flux to provide a medium, a high purity brightened and anodized reflector shall be housed in the luminaire.

Luminaire shall be gasketed to provide a weather proof seal with the lower rim of the body and shall be supported by quick release stainless steel toggle catches. Filtered breathing shall be provided for either thru a separate filter or thru filter gasket.

The bridge luminaires are 9W and 7W LED

- C. Luminaires Type – Bollard Mounted

Bollard lightings: 0.75 to 1.2 metre-mounting heights. The bollard shall have either a 70-watt sodium lamp as required. The bollard shall be made to the dimensions and style shown in the Drawings. The lampholder shall be weatherproof ceramic, designed for firm lamp support. Typical applications are for aesthetic and accent lighting, for example in landscaped areas, parks, shopping arcades etc.

- D. Luminaires Types – Wall Mounted

Wall mounted luminaires may be installed either inside the concrete block wall flush with the surface or attached to the outer surface of the wall in the manner specified and detailed in the Drawings. The housing for the luminaire shall be one-piece aluminum casting of an alloy containing less than 0.3% copper to prevent corrosion when cast in concrete.

A cast aluminum junction box may be attached to the luminaire housing and enclosed by a removable cover. The interior volume of the junction box shall contain four threaded taps, two with removable plugs. A temporary cover shall be furnished to keep the housing clean until the electrical components are to be installed.

The luminaires' door frame shall be one-piece aluminum casting with a fine pebbled texture on the outer surface. Trapezoidal outer contour shall tilt the refractor 18° from vertical.

The refractor shall be tempered borosilicate glass with a smooth outer surface flush with the doorframe, and vertical inside flutes. An optical injection molded (in lieu of glass) refractor shall be provided if shown in the Drawings. It shall be identical in appearance to the glass refractor and contain an ultra violet inhibitor.

A silicon rubber gasket shall be installed between the door frame and housing. A neoprene gasket shall be provided between the junction box and housing. The entire luminaire shall be weather

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tight.

Reflector shall be one piece hydro formed aluminum the bottom surface shall be finished in matte black to prevent any escape of upward light.

#### 4. MEASUREMENT AND PAYMENT

<b>Item</b>	<b>Description</b>	<b>Unit</b>
<b>SS85.20</b>	<b>Exterior Lighting</b>	
(a)	165W LED Street Light.....	Number (no)
(b)	9W LED for the bridge.....	Number (no)
(c)	7W LED for the bridge.....	Number (no)

The unit of measurement shall be the number of complete functional exterior lighting.

The tendered rate shall include full compensation for procuring, transporting, installation, testing, and commissioning of all materials required for the exterior lights as specified.

**SECTION 8620: TRAFFIC SIGNAL SYSTEM**

**1. MEASUREMENT AND PAYMENT**

<b>Item</b>	<b>Description</b>	<b>Unit</b>
<b>SS86.21</b>	<b>Supply and install, test and commission the Traffic Signal System</b>	
(a)	Traffic Signal System Controller c/w Microprocessor based, fully electronic. Modular in design for easy maintenance. Upgradeable from 4 to 24 phases. LED phase indicators on the driver modules. Dual Green to Green Conflict Monitoring. Last Red out monitoring. Selectable Lamp Monitoring for LED, Incandescent. Front connecting cable looms for quick & easy replacement. SD card for configuration transfer and download. Fuse protected driver output PSU with LED indicators. 16 Detector inputs & 8 auxiliary inputs. External Flasher facility. Advanced Manual Panel facility. Communication: GPRS, Wi-Fi, LAN and Zigbee. GPS Real-time clock for wireless synchronisation. Hand Held Unit for easy diagnostics. Cabinet should have a 3-way locking mechanism .....	Number (no)
(b)	Construction of the Plinth for the Traffic Light Panel .....	Number (no)
(c)	2 no of Fixed CCTV Camera for One Traffic Light and the Bridge, The D-Link as per DCS-7513 or equal make for the Full HD WDR Day & Night Outdoor Network Camera for a high-definition professional surveillance and security road solution suitable for the two carriage highway. The camera should use a high-sensitivity 2-megapixel progressive scan CMOS sensor with a motorised P-Iris lens and onboard WDR image enhancement to deliver superior quality video with up to 1080p resolution at 60 fps in all conditions. The all-in-one durable designed to make this camera ideal for reliable deployment in road and bridge surveillance applications without the need for accessories. 1 no of CCTV Active Controller linked and connected to Traffic Light Controller/Microprocesso, GPRS and LAN. and its Panel mounted and embedded inside/on top of the traffic light/electrical panel with all necessary outdoor 100m roll of cabling Cantiliver Mounted .....	Number (no)
(d)	Liaise with TTCL for supply and installation of telecommunication network at the CCTV Panel at the Bridge.....	Provisional Sum (PS)
(e)	Allow for contractor's overhead and profit as percentage of sub item 86.21(d).....	Percent (%)

The unit of measurement shall be the complete number of traffic signal systems installed. The secondary unit of measurement shall be the provisional sum for the liaison with TTCL for the installation of the telecommunication network between traffic signal systems.

The tendered rate shall include full compensation for procuring, transporting, installation, testing, and commissioning of all materials required for the traffic signal system as specified.

<b>Item</b>	<b>Description</b>	<b>Unit</b>
<b>SS86.22</b>	<b>Supply and erection of poles:</b>	
(a)	The Automotor steel baseplate and frame for high and cantilever poles and placing thereof as per Type D.....	Number (no)
(b)	Standard height traffic signal pole, 4,5m long, 110mm outside diameter including cable entry hole as per Pedestrian Type F, painted with 2 coats of anti corrosive paint.....	Number (no)
(c)	Supply and erection of totem (high) traffic signal pole, including cable entry hole, Automotor Type, painted with 2 coats of anti corrosive paint.....	Number (no)
(d)	Cantilever traffic signal pole, including cable entry hole, Automotor Type, as per Type F, painted with 2 coats of anti corrosive paint.....	Number (no)

The unit of measurement shall be the complete unit of traffic signal pole type.

The bid rates shall include full compensation for providing, testing, loading, transporting and unloading the poles, for the installation of the poles in final position as per drawings, and any other activity deemed necessary for supply and erection of signal poles in final position as per specifications.

Item	Description	Unit
<b>SS86.23</b>	<b>Painting of poles with golden yellow paint</b>	
(a)	Standard height poles as per Type F.....	Number (no)
(b)	Totem (High) poles.....	Number (no)
(c)	Cantilever poles as Type D.....	Number (no)

The unit of measurement shall be the complete unit of traffic signal pole type.

The bid rates shall include full compensation for providing, testing, loading, transporting and unloading the material, for the painting of the poles in their final position as per drawings, painting of two (2) coats of paint, Galvo grip and Golden Yellow, and any other activity deemed necessary for painting of signal poles in final position as per specifications.

Item	Description	Unit
<b>SS86.24</b>	<b>Cables and Wiring</b>	
(a)	305m 27x1.5mmsq cable .....	Roll (Roll)
(b)	305m 12x1.5mmsq cable .....	Roll (Roll)
(c)	305m 1x1.5mmsq earth wire .....	Roll (Roll)
(d)	Earth rods.....	Number (no)
(e)	Cable glands.....	Pair (pair)
(f)	Wiring of traffic light points wired using 1.5mmsq pvc/swa/pvc 2 core cable drawn in underground and duct of 100mm dia surrounded by concrete and including all necessary accessories .....	Number (no)

The unit of measurement shall be the roll of cable as specified. The secondary unit will be the number of earth rods instakled as well as the number of traffic light points wired. The tertiary unit of measurement will be the pair of cable glands.

The bid rates shall include full compensation for providing, testing, loading, transporting and unloading the material for supply and laying of cables, armoured cable including supply and draw of cable through ducts, laying in trenches and connection at end, and any other activity deemed necessary for the supply and wiring of cables as per specifications.

Item	Description	Unit
<b>SS86.25</b>	<b>Traffic signal head on poles, including labour and back board:</b>	
(a)	Type F LED.....	Number (no)
(b)	Type D LED.....	Number (no)
(c)	Type D LED PEDESTRIAN.....	Number (no)

The unit of measurement shall be the complete number of units as specified.

The bid rates shall include full compensation for providing, testing, loading, transporting and unloading the material for supply and installation of traffic signal head on poles, including labour and back board, and any other activity deemed necessary for supply and installation of signal heads as per specifications.

Item	Description	Unit
<b>SS86.26</b>	<b>Draw boxes for traffic signals as persignal set:</b>	
(a)	Supply and install complete Draw boxes for traffic signals .....	Number (no)

The unit of measurement shall be the complete unit including all concrete, brickwork, covers, frames, grids and other accessories.

The tendered rate shall include full compensation for procuring, furnishing and installing the complete

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units and for excavation and backfilling around the unit with selected material. The tendered rate shall also include full compensation for connecting conduits from draw box to signals.