

## **SECTION 16510**

### **INTERIOR BUILDING LIGHTING**

#### **PART 1 - GENERAL**

##### **1.01                      DESCRIPTION**

- A.     The work to be performed includes, but is not necessarily limited to supply, installation, connection and testing of all the interior lighting system.

##### **1.02                      QUALITY ASSURANCE**

- A.     The Contractor is responsible for the quality of all its purchased items and as such, must develop and submit a Supplier Quality Inspection Plan for review by the Engineer. The inspection plan shall cover those items intended for shop inspection and the procedures for carrying out same.
- B.     Manufacturer: The components of the interior building lighting shall be the standard products of a manufacturer regularly engaged in manufacture of such components of types and sizes required and complying with the requirements of the listed standards and whose products have been in satisfactory use in similar service for not less than 5 years.
- C.     Codes and Standards: Comply with requirements of the following codes and standards except as herein modified.

1.	BS I	British Standard Institution
	BS 3677	Specification for high pressure mercury vapour lamps.
	BS 3772	Specification for starters for fluorescent lamps.
	BS 4533	Luminaires.
	BS 5042	Specification for bayonet lampholders.
	BS 5225	Photometric data for luminaires.
	BS 5266	Emergency lighting.
	BS 5499	Fire safety signs, notices and graphic symbols.
	BS 8206	Lighting for buildings.

	BSEN 60081	Specification for tubular fluorescent lamps for general service.
BSEN 60238		Specification for Edison screw lamp holders.
BSEN 60400		Specification for lamp holders for tubular fluorescent lamps and starter holders.
BSEN 60730-2-3		Thermal protectors for ballast for tubular fluorescent lamps.
BSEN 60920		Specification for ballasts for tubular fluorescent lamps. General and safety requirements.
BSEN 60921		Specification for ballasts for tubular fluorescent lamps. Performance requirements.
BSEN 60922		Specification for general and safety requirements for ballasts for discharge lamps (excluding tubular fluorescent lamps).
BSEN 60923		Specification for performance requirements for ballasts for discharge lamps (excluding tubular fluorescent lamps).
BSEN 60928		Specification for a.c. supplied electronic ballasts for tubular fluorescent lamps. General and safety requirements.
BSEN 60929		Specification for a.c. supplied electronic ballasts for tubular fluorescent lamps. Performance requirements.
BSEN 61048		Specification for capacitors for use in tubular fluorescent and other discharge lamp circuits. General and safety requirements.
BSEN 61049		Specification for capacitors for use in tubular fluorescent and other discharge lamp circuits. Performance requirements.
2.	IEC	International Electrotechnical Commission:
	IEC 60081	Tubular fluorescent lamps for general lighting service.

IEC 60 155	Starters for tubular fluorescent lamps.
IEC 60188	High pressure mercury vapour lamps.
IEC 60238	Edison screw lampholders.
	IEC 60400            Lamp holders for tubular fluorescent lamps and starter holders.
IEC 60598	Luminaires.
IEC 60882	Pre-heat requirements for starterless tubular fluorescent lamps.
IEC 60920	Ballasts for tubular fluorescent lamps. General and safety requirements.
IEC 60921	Auxiliaries for lamps - Ballasts for tubular fluorescent lamps. Performance requirements.
IEC 60922	Auxiliaries for lamps - Ballasts for discharge lamps (excluding tubular fluorescent lamps). General and safety requirements.
IEC 60923	Auxiliaries for lamps - Ballasts for discharge lamps (excluding tubular fluorescent lamps). Performance requirements.
IEC 60926	Auxiliaries for lamps - Starting devices (other than glow starters). General and safety requirements.
IEC 60927	Auxiliaries for lamps - Starting devices (other than glow starters). Performance requirements.
IEC 60928	Auxiliaries for lamps - A.C. supplied electronic ballasts for tubular fluorescent. General and safety requirements.
IEC 60929	A.C. supplied electronic ballasts for tubular fluorescent lamps. Performance requirements.
IEC 61048	Capacitors for use in tubular fluorescent and other discharge lamp circuits. General and safety requirements.

IEC 61049

Capacitors for use in tubular fluorescent and other discharge lamp circuits. Performance requirements

1.03

TESTS AND ACCEPTANCE CRITERIA

- A. Equipment Test: Unless requirement is waived, materials shall be tested and manufacturer's test reports certifying that materials meet the requirements of the listed standards shall be submitted.

1.04

SUBMITTALS

- A. The Contractor shall submit to the Engineer the required documents to establish compliance with this section. Submittal shall include at least the following:
1. Manufacturer's Data: Submit following manufacturer's data:
    - a. Full detailed technical Manufacturer Catalogues showing the type of the fitting proposed, photometric data, rated voltage, max. working temperature, type and size of internal wiring etc.
    - b. Full technical details of the ballast including manufacturer, type of insulating material, max. temperature rise.
    - c. Full technical details of the power factor correction capacitor, including manufacturer, voltage, frequency, capacitance, number, integral discharge resistor etc.
    - d. Sample of each of the proposed lighting fitting to be submitted where requested.
  2. Shop Drawings: Including dimensioned drawings of each luminaire dimensioned reflected ceiling lighting layout.

PART 2 - PRODUCTS

2.01

LUMINAIRE

- A. The types of luminaires for interior lighting required shall include the following:
- a. Fluorescent type luminaires.
  - b. High intensity discharge luminaire
- B. The applications of luminaires for interior lighting shall include the following:
- a. General lighting.

- b. Emergency lights.
- C. Luminaires shall be of the type, size and rating indicated on the drawings, complete with, but not necessarily limited to, lamps, lampholders, reflectors, diffusers, baffles, visors, control gear and wiring to form a complete unit to allow the luminaire to function and produce the photo metric performance in accordance with manufacturers published data and/ or that specified here in.
- D. Luminaires shall be suitable for trouble free use on 230 Volts, 50 Hertz.
- E. Each luminaire shall be protected against environmental conditions in which the luminaire will be installed and shall comply with individual specification of each type of luminaire described.
- F. Wiring: Within the luminaire, the wiring shall not be less than 1.0mm<sup>2</sup>.
  - 1. Insulation within luminaires shall be silicone rubber for the lower temperatures (fluorescent luminaires) and shall be thermal resistance flame retardant for the higher temperature.
- G.
  - 1. All luminaires shall be capable of operating continuously in the ambient conditions specified.
  - 2. Any reduction in performance due to abnormal ambient or operating conditions shall be notified at the time of submittal.
- H. All luminaires shall be suitable for mounting on or suspension from a conduit box or mounting to a flat surface and shall be complete with conduit or glanded cable entry facility.

## 2.02 FLUORESCENT LUMINAIRES

- A. The luminaires shall be as specified on luminaires schedule drawing.
- B. Construction:
  - 1. Sheet steel housings used in luminaires shall not be less than 0.6 mm or heavier when required. Sheet steel reflectors shall have a thickness of not less than 0.8 mm. Aluminium reflectors shall have a thickness of not less than 1mm.
  - 2. All metal work shall be mitered, welded and smoothed. The metal parts of the luminaire shall be completely free from burrs and tool marks. Solder shall not be used in any part of the luminaire for jointing.
  - 3. Ferrous metal sheets shall be galvanized, copper plated, given a corrosion-resistant phosphate treatment or other approved rust-

inhibiting prime coat, to provide a rustproof base before application of finish.

4. Luminaires with visible frames shall have concealed hinges and catches. Hinged diffuser doors shall be provided with stainless steel clips or equal retaining devices of non-corroding materials.

5. Recessed luminaires shall be constructed so that control gear is replaceable without removing housing from ceiling.

2.03

DISCHARGE LAMP LUMINAIRES

A. General:

1. Discharge lamp luminaires shall be of a type as specified on the drawings.
2. They shall generally be of a type suitable for use with mercury vapour metal halide or sodium vapour type lamps and shall have integral control gear unless otherwise specified.
3. Where control gear is to be separately mounted it shall be completely enclosed in a metal clad type enclosure complete with conduit entry facilities and fixing accessories.
4. Power factor correction capacitors shall be supplied of adequate rating to provide an overall circuit power factor not less than 0.9 lagging.

B. Internal Luminaires: Luminaire enclosures for internal use shall be fabricated from polycarbonate or from sheet steel finished in a corrosion and abrasion resistant paint finish or shall be of cast alloy similarly resistant to corrosion or abrasion. All enclosures shall be complete with conduit or glanded cable entry and all necessary support and fixing accessories.

C. External Luminaires Type C

1. Luminaires for external use shall be weatherproof pattern designed for wall, pole or column mounting. Degree of protection shall be at least IP55 but preferably IP65.
2. Luminaires shall be capable of accepting mercury or sodium vapour lamps of the type specified on the drawings. They shall conform to the requirement of BS 4533 and shall have light output characteristics and controls suitable for use on each class of footpath and/or roadway lighting as specified and defined in BS 5489.
3. Luminaires shall be corrosion and vandal resistant. Luminaires using acrylic type diffusers shall be UV stabilised.

2.04                      EMERGENCY LIGHTING

- A.     The emergency lighting shall be as specified on drawings.
- B.     Self-contained emergency lights, suitable for use on 220 volt, 50 Hz current and shall consist of:
  - 1.     Battery with a capacity of at least 3 hours for operation in case of power failure.
  - 2.     Automatically controlled, solid-state, two-rate charger.
  - 3.     A transfer relay.
  - 4.     Switch for controlling the lamp circuit.
  - 5.     Signals to indicate when the lamp circuit is in position to provide emergency protection, and to indicate high-charge rate.
  - 6.     Test switch for testing the lamps and battery.
  - 7.     One (1) 8W tube or as appropriate.
  - 8.     Appropriate indication and arrow or exit lights.
  - 9.     Nickel cadmium battery.

2.05                      HIGH BAY LUMINAIRE CLASS M

- A.     General
  - 1.     The class M luminaires shall consist of high bay industrial indoor type lighting fittings.
  - 2.     Each luminaire shall have a reflector, a control gear housing, a control gear, a high intensity discharge lamp a mounting system and if called for in the luminaire schedule a glass cover and a wire guard.
  - 3.     The luminaires shall have a low overall depth and an integral control gear.
  - 4.     The luminaires shall be suitable for mounting height equal or exceeding 6m.
- B.     Reflector
  - 1.     The luminaires shall be equipped with an anodised aluminium reflector of narrow, semi-wide or wide beam as indicated in the luminaire schedule.

2. The spacing to the mounting height ratio SHR shall be less than the following values:
  - a. Narrow beam  $SHR \leq 0.75$
  - b. Semi-Wide beam  $SHR \leq 1.25$
  - c. Wide beam  $SHR \leq 1.50$

C. Control Gear Housing

1. The control gear shall be housed in a die-cast anti-corrosive aluminium box.
2. Knock outs shall be provided in the gear box to generate a current of air through the reflector. Another method of ventilation may be submitted and considered by the Engineer.

D. Degree of Protection IP

1. The luminaire shall have the degree of protection indicated in the luminaire schedule.
2. The luminaire shall be of IP 54 if the knockouts are intact and dust cover fitted.
3. The luminaire shall be of IP 20 if the knock outs are removed and no dust cover provided.

E. Lamps

1. The luminaires shall be provided with a high intensity discharge lamps of the type and watts indicated in the luminaire schedule.
2. The high pressure sodium lamps shall be one of the following as indicated in the schedule.
  - a. Increased efficacy  
150 W SON PLUS - 250 W SON PLUS - 400 W SON PLUS
  - b. Improved colour rendering  
150 W SON COMFORT - 250 W SON COMFORT  
- 400 W SON COMFORT
3. The high pressure mercury vapour lamp shall be one of the following as indicated in the schedule:
  - a. Standard 250 W HPL -N , 100 HPL-N
  - b. High rendering and high efficiency of 250 W COMFORT,  
400 W COMFORT

F. Accessories

1. Where indicated the reflector shall be sealed with a glass cover to assure a protection degree of IP 54. A wire guard will be added if specified.

G. Mounting System

1. The luminaires shall be equipped with one of the following mounting systems:
  - a. Combination of suspension bracket with suspension tube.
  - b. Twin mounting rail for two luminaires on universal mounting rail.
  - c. Chain suspension by universal mounting rail.

2.06 LAMPS

A. The type of lamps required shall include the following:

1. Tubular Fluorescent.
2. Compact fluorescent
3. Sodium vapour discharge lamp.
4. Metal halide discharge lamps

B. Fluorescent tubes shall be rated 18 w, 36 w, or 58 w as specified on drawings.

1. Lamps shall have the following colour characteristics unless otherwise specified:

Colour Temperature: 3000°K.

General Index (Ra): Not less than 85.

Colour Temperature: 4100°K.

General Index (Ra): Not less than 66.

Lamp shall be of standard length as required by specified luminaire with 18,000 hour average life and suitable for use with specified control gear.

C. Compact Fluorescent Lamps:

Lamps shall have ratings and colour characteristics as specified on drawings and shall be suitable for specified control gear.

D. Sodium Vapour Discharge Lamps:

1. Sodium vapour discharge lamps shall be of low pressure type (SX) in accordance with the requirements of BS or high pressure type (SON) with preference being given to SON type as indicated on the drawings.
2. Lamps shall be suitable for operation in the cap position required in the luminaire in which it is intended they are to be used. The lamps shall

be capable of maintaining an average life of 8000 hours with an average light output of approximately 100 lumens/watt for SON type lamps and 140 lumens/watt for SOX type lamps.

E. High Pressure Mercury Vapour Lamp

a. The lamp shall comply with the following requirements:

1. Power into the lamp : 250 watts ( mercury vapour)
2. Total luminous flux: 11,500 lumens.
3. Average life to burn out to exceed: 24,000 hours.
4. At half life, the maintained luminous flux shall be a minimum of 80 percent of the initial luminous flux.

F. Metal halide lamp.

Metal halide lamps shall be double ended, UV-reduced lamps having rating and colour characteristics as specified on drawings.

2.07 CONTROL GEAR

A. Provide gear.

B. High frequency electronic ballasts shall be hum and flicker free, protected against over voltage, instant start within 0.3 seconds, with integrated safety shutdown of defective lamps, automatic switch-on after lamp replacement and suitable to be used in emergency lights.

C. Ballasts for tubular fluorescent lamps shall be high power factor not less than 0.90 and shall comply to IEC 60920/60921. Ballast operating temperature shall not exceed 120°C at rated temperature rise of 55°C. Only single and two lamp ballasts shall be used in fluorescent luminaires.

D. Ballasts for high intensity discharge lamps shall be high power factor, constant wattage auto transformer type. Core and coil assembly shall be potted together in an insulating compound (105°C minimum) and enclosed in a metal housing. Capacitor may be potted together with coil and core or mounted separately.

E. Ballast filling compound shall be thermo-setting type which shall not support combustion and shall be non-melting.

F. The starter switch shall be electronic type of instant starting. Each starter shall be of 2 pin type contained in proper canister.

G. Radio interference suppression capacitor system shall be provided for each fitting.

H. Lamp-holders and starters-holders shall be of good heat resisting insulating

material capable to prevent, in extended normal use, any electrical or mechanical failure. Contacts shall be resilient and shall provide adequate contact pressure.

- I. The arrangement and type of the lamp and starter holders shall make replacement of lamp and starter feasible.
- J. Earthing terminal shall be provided for each fitting.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION STANDARD

- A. Internal Luminaires: Luminaires shall be arranged for surface or pendant mounting as required by the general structure and decor of the building. Where a suspended ceiling is provided, recess mounted luminaires shall be fitted unless otherwise specified or noted on the drawings. All conduit boxes for mounting off luminaires shall be metal. PVC boxes shall not be used.
  - 1. Surface Mounted:
    - a. All surface or pendant mounted luminaires shall be fixed to a surface or flush mounted metal conduit box. Direct surface mounted luminaires shall be spaced a distance of 12 mm from the mounting surface by using extension rings.
    - b. The connection between the permanent wiring and the luminaire shall be made using 150°C rated cable. The cable shall be connected using a porcelain or heat resistant connector block housed in the conduit box.
    - c. Luminaires shall not constitute part of the circuit wiring route to other luminaires.
    - d. The removal of any one luminaire shall not prevent normal operation of other luminaires.
  - 2. Recess Mounted:
    - a. All recess mounted luminaires shall preferably be suspended independently of the ceiling in which they are fitted. Where such an arrangement is not possible or practical and the luminaires are to be fitted in and supported by the ceiling, the Contractor shall ensure that the suspended ceiling is suitably strengthened to carry the additional weight.
    - b. The connection between the permanent wiring and the luminaire shall be made using a heat resistant flexible cable connected to a 2 amp 3 pin plug and socket, conduit box

mounted adjacent to the luminaire and accessible on removal of the luminaire.

- c. The flexible cable shall be three core type, one core being used as the circuit protective and earth bonding conductor. Where the cable forms the connection to a tungsten lamp luminaire it shall be rated for operation at 150°C minimum.
- d. The minimum cross-sectional area of any conductor forming part of a multi-core flexible cable shall be 1 sq. mm.
- e. All recess mounted luminaires shall be designed and fitted to give access for lamp replacement and general maintenance from below, unless otherwise specified.

3. Pendant Luminaires:

- a. Tube pendants shall be mounted from a ball and socket type swivel dome cover plate fitted to a ceiling mounted metal conduit box and conduit of minimum diameter 20 mm. The conduit entry to the luminaire shall be fitted with a lock nut and a flexible copper bond shall be provided from the fixed conduit installation to the pendant tube.
- b. Proprietary type pendant luminaires, whether single or multi-lamp units, shall be bonded and provided with suitable terminations to ensure reliable earth continuity throughout all exposed metalwork.
- c. Luminaires longer than 600 mm shall have one additional support besides the outlet box stud unless otherwise required. Stems shall be distant by at least 3/4 the length of luminaire.

B. External Luminaires: Luminaire located on the exterior of the building shall be installed with non-ferrous metal screws finished to match the luminaire.

C. General:

- 1. Flush mounted recessed luminaires shall be installed so as to completely eliminate light leakage within the luminaire, and between the luminaire and adjacent finished surface.
- 2. Luminaire housing, frame or canopy shall provide a suitable cover for the luminaire outlet box or luminaire opening.
- 3. Indoor luminaire positions shown on the drawings shall not be scaled. The Contractor shall coordinate the exact luminaire position with the false ceiling tiles, air outlets and with any other equipment or building details involved.

4. Certain luminaires are shown in provisional position. They shall be exactly located as soon as the final layout of the equipment is known and lay-out submitted for approval to the engineer.
5. Luminaires shall be installed at the indicated heights shown on the drawings or indicated in the specification.
6. Pendant luminaires within the same room or area shall be installed, aligned, plumb, and at a uniform height from the finished floor.

\*\* END OF SECTION \*\*

**SECTION 16120**

**WIRES AND CABLES**

**PART 1 - GENERAL**

**1.01**                      **DESCRIPTION**

- A. The work to be performed includes, but is not necessarily limited to, all work involved with the supply and installation of wires and cables and the associated connectors and terminal boards used in electrical power distribution systems.
- B. The types of wires and cables specified in this section include the following:
  - 1. Power cables (Insulated & Sheathed)
    - a. Single Core PVC insulated and sheathed 600/1000V cables.
    - b. Single core XLPE insulated PVC sheathed (600/1000V) cables.
    - c. Multi-core PVC cables (600/1000V) non-armoured cables.
    - d. Multi-core PVC/SWA/PVC cables (600/1000V).
    - e. Multi-core XLPE/PVC (600/1000V).
    - f. Multi-core XLPE/SWA/PVC (600/1000V).
    - g. Mineral insulated cable.
  - 2. Small power and lighting cables (Insulated)
    - a. Single core PVC insulated cables (450/750V).
  - 3. Signal/Instrument cables.
  - 4. Data transmission cables.

**1.02**                      **QUALITY ASSURANCE**

- A. The Contractor is responsible for the quality of all purchased items and as such must develop and submit a supplier Quality Inspection Plan for review. The inspection plan shall cover those items intended for shop inspection and the procedures for carrying out same.
- B. Manufacturer: Cables and wires shall be the products of a manufacturer regularly engaged in manufacture of cables and wires of types

and sizes required and complying with the requirements of the listed standards and whose products have been in satisfactory use in similar service for not less than 5 years.

C. Codes and Standards: Comply with requirements of the latest edition of the following codes and standards except as herein specified:

1. BSI - British Standard Institution:

BS 1442	Specification for galvanized mild steel wire for armoured cable.
BS 4109	Specification for copper for electrical purposes. Wire for general electrical purposes and for insulated cables and flexible cords.
BS 5308	Instrumentation Cables
BS 5467	Specification for cables with thermo-setting insulation for electricity supply for rated voltages of up to and including 600/1000V and up to and including 1700/3300V.
BS 6004	Specification for PVC insulated cables (non-armoured) for electric power and lighting.
BS 6007	Specification for rubber-insulated cables for electric power and lighting.
BS 6081	Specification for terminations for mineral insulated cables.
BS 6121	Mechanical cable glands
BS 6207	Specification for mineral insulated copper-sheathed cables with copper conductors.
BS 6234	Specification for polyethylene insulation and sheath of electric cables.
BS 6346	Specification for PVC insulated cables for electricity supply.
BS 6360	Specification for conductors in insulated cables and cords.
BS 6469	Methods of test for insulation and sheaths of electric

cables.

- BS 6500 Specification for insulated flexible cords and cables.
- BS 6746 Specification for PVC insulation and sheath of electric cables.
- BS 7671 Requirements for electrical installations.
- BS 7655 Elastomeric sheathing compound.
- BS 7769 Electric cables calculation of the current rating.

2. IEC - International Electrotechnical Commission

- IEC 60227 Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V.
- IEC 60228 Conductors of insulated cables.
- IEC 60230 Impulse tests on cables and their accessories.
- IEC 60245 Rubber insulated cables or rated voltages up to and including 450/750V.
- IEC 60287 Electrical cables calculation of the current rating.
- IEC 60364 Electrical installation of buildings.
- IEC 60702 Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V.
- IEC 60724 Guide to the short circuit temperature limits of electric cables with a rated voltage not exceeding 0.6/1.0 KV.
- IEC 60811 Common test methods for insulating and sheathing materials of electric cables.
- IEC 60853 Calculation of the cyclic and emergency current rating of cables.
- IEC 60885 Electrical test methods for electric cables.

1.03

TESTS AND ACCEPTANCE CRITERIA

- A. Field testing: Prior to energization, cables and wires shall be checked for the following:

1. Continuity of circuitry.
  2. Short circuits.
  3. Insulation resistance test, including procedure, equipment required (such as 500V megger) and acceptable values for resistance in accordance with recognized standards.
- B. Malfunctions shall be corrected when detected.
- C. Subsequent to wire and cable hook-ups circuitry shall be energized and circuits tested for performance in accordance with all requirements.

#### 1.04 SUBMITTALS

- A. The Contractor shall submit to the Engineer the required documents to establish compliance with this section. Submittal shall include at least the following:
1. Manufacturer's Data: Including specifications, installation instructions dimensions and general recommendations for each type of cable.
  2. Shop Drawings: Dimensioned drawings of cables routing showing accurately layouts of cables installation and their special relationship to associated equipment and details of installation.
  3. Across sectional drawing of the cable bedding, sanding, tiles, warming, back fill.
  4. Shop Drawings: Dimensioned drawings of cables routing showing accurately layouts of cables installation and their spatial relationship to associated equipment and details of installation.
  5. Test Certificates: Manufacturer shall submit against each drum, the following certificates:
    - a. High voltage DC insulation pressure test, between cores each core to earth metallic sheath or armour as applicable.
    - b. Insulation resistance test
    - c. Core continuity and identification
    - d. conductor resistance test

### PART 2 - PRODUCTS

#### 2.01 GENERAL

- A. Cables shall be manufactured and tested to the latest relevant British or harmonized European Standards or IEC.
- B. The cable sheath shall be marked with the information required by the relevant

BS, BS EN or IEC.

- C. Cables shall be delivered, stored and handled in accordance with the manufacturers instructions. Where the performance of the cable is likely to be adversely affected by the ingress of moisture, it shall be adequately sealed at either end.
- D. Unless otherwise specified, the outer sheath of all cables shall be coloured black for grade 600/1000 V with the exception of the following:
  - 1. Protective conductors: - Green/yellow; and
  - 2. Intrinsically safe: - Blue
- E. Cables shall have copper conductors to BS 4109/BS 6360. Cores of cross sectional area greater than 2.5 mm<sup>2</sup> shall be stranded or flexible.
- F. The scheme of wiring shall conform to the colour code requirements of BS 7671.
- G. Cables shall be delivered, stored, and handled in accordance with the manufacturers instructions. Where the performance of the cable is likely to be adversely affected by the ingress of moisture, it shall be adequately sealed at either end.
- H. The general routing of cables shown on the Drawings is indicative of the final routes and duct locations shall be agreed with the Engineer before any work in connection with the cable installation is commenced. all cables shall be installed in strict accordance with the requirements of this Specification.
- I. All cables used shall bear the manufacturer's original guarantee and all cables shall be delivered to Site in their original wrappings.

## 2.02 SINGLE CORE PVC INSULATED AND SHEATHED CABLES

- A. This type of cable shall be 600/1000V grade, complying with BS 6346 and shall have stranded conductors of plain annealed copper wires.
- B. The conductor shall be PVC insulated.
- C. Over the insulated conductor an outer protecting layer of extended PVC layer shall be applied.

## 2.03 SINGLE CORE XLPE INSULATED AND PVC SHEATHED CABLES

- A. This type of cable shall be 600/1000V grade, complying with BS 5467 and shall have stranded conductors of plain annealed copper wires.
- B. The conductor shall be XLPE insulated.

- C. Over the insulated conductor an outer protecting layer of extended PVC layer shall be applied.

#### 2.04 MULTICORE PVC/PVC 600/1000 V NON-ARMoured CABLES

- A. This type of cable shall be 600/1000V grade complying with BS 6346. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be PVC insulated and the cores insulation shall be coloured for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extended PVC in order to fill the interstices between the cores.
- D. A black outer protecting layer of extended PVC shall be applied over the bedded cables.

#### 2.05 MULTICORE PVC/SWA/PVC 600/1000V ARMoured CABLES

- A. This type of cable shall be 600/1000 grade complying with BS 6346, multi-core. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be PVC insulated and the cores insulation shall be coloured for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extended PVC in order to fill the interstices between the cores.
- D. Over the bedding is helically applied a layer of galvanized steel wires in such a way to form a continuous metallic protecting cover.
- E. Over the armoured cable, an outer black protection layer of extended PVC shall be applied.
- F. A single core cable shall have aluminium wire armour.

#### 2.06 MULTICORE XLPE/PVC 600/1000V NON-ARMoured CABLES

- A. This type of cable shall be 600/1000V grade complying with BS 5467, multi-core. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be XLPE insulated and the core insulation shall be coloured for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extended PVC in order to fill the interstices between the cores.
- D. A black outer protecting layer of extended PVC shall be applied over the bedded cables.

## 2.07 MULTICORE XLPE/SWA/PVC 600/1000V ARMOURED CABLES

- A. This type of cable shall be 600/1000 grade complying with BS 5467, multi-core. The core shall have stranded conductors of plain annealed copper wires.
- B. The cores shall be XLPE insulated and the cores insulation shall be coloured for identification as per BS 7671.
- C. The assembled cable shall be bedded with a layer of extruded PVC in order to fill the interstices between the cores.
- D. Over the bedding is helically applied a layer of galvanized steel wires in such a way to form a continuous metallic protecting cover.
- E. Over the armoured cable, an outer black protection layer of extended PVC shall be applied.
- F. A single core cable shall have aluminium wire armour.

## 2.08 MINERAL INSULATED CABLES

- A. PVC Sheathed MICC Cables: 750 Volts MICC cables shall have conductors of high conductivity solid copper, insulated with compressed powdered minerals chemically stable up to 600°C, sheathed with deoxidised copper, with an overall extruded PVC covering red colour for fire systems otherwise orange and complying in all respects with IEC 60702/BS 6207, Part 1. Where cables run buried in wall or in floor screeds special attention shall be given to the termination at flush type switches to ensure that glands are not buried directly in walls. In such location, glands shall be provided with plastic shroud.
- B. Seals for MICC cables shall be of the cold screw-on pot type consisting of a brass pot complete with anchoring wedges and caps. Glands shall be of the Ring type, of free machined brass with a compression type cone grip at one end and the other end screwed male to BS conduit and complete with lock nut. All saddles if required, shall be of copper of the spacer bar stand-off pattern. All MICC installation shall be carried out by competent personnel.

## 2.09 SINGLE CORE PVC

- A. Cables shall comply with BS 6004, Table 1/ IEC 60227 and be rated at 450/750V.
- B. The insulation shall be phase coloured.

## 2.10 SIGNAL AND INSTRUMENTATION CABLES

Instrumentation cables unless otherwise indicated, shall be rated 300/500 V and comply with BS 5308 type 2.

Cables shall be PVC or polyethylene insulated twisted pair with individual or

collective metallic foil screen, tape bound with extended PVC bedding, galvanized steel wire armouring and coloured overall PVC sheath. Conductors shall be multi-strand copper, 24/0.2 mm (0.75 mm<sup>2</sup>) or as indicated.

1. Collection screened cables shall be used only with measuring transmitters and analogue controllers (4-20 mA d.c.) up to 30 m route length.
2. Individual and collective screened cables shall be used:  
For circuits as in (1) but exceeding 30 m route length and for inputs to data loggers, telemetry systems, microprocessors, computer, also cable to transducers.

## 2.11 DATA TRANSMISSION CABLES

- A. Defined as extra low voltage, digital signalling cables between computers, programmable logic controllers (PLCS) and remote telemetry units (RTUS) and other data transmission equipment.
- B. The minimum cross sectional area of cable conductors shall be 0.5 mm<sup>2</sup>.
- C. The following types of cable may be used:
  1. Those complying with BS 5308: Parts 1 & 2;
  2. Belden or equivalent;
  3. UTP Category 5; and
  4. Those specified by the equipment manufacturer.
- D. PE or PVC/IS (individually screened)/SWA/PVC and PE or PVC/CS (Collectively Screened)/SWA/PVC (Multi-pair).
  1. PE insulated cables shall comply with BS 5308: Part 2 (type 2), with each core identified according to table 12, Appendix A.
  2. PVC insulated cables shall comply with BS 5308: Part 1 (type 2), with each core identified according to table 11, Appendix A.
  3. Cables shall have stranded, copper conductors.
- E. PE or PVC/IS/PVC and PE or PVC/CS/PVC (multi-pair)
  1. PE insulated cables shall comply with BS 5308: Part 1 (type 1), with each core identified according to table 12, Appendix A.
  2. PVC insulated cables shall comply with BS 5308: Part 2 (type 1), with each core identified according to table 11, Appendix A.
  3. Cables shall have stranded, copper conductors.

## PART 3 - EXECUTION

### 3.01 INSTALLATION OF CABLES GENERAL

- A. All cables shall be installed in accordance with the applicable provisions of BS

7671/IEC 60364 and as indicated on the drawings.

- B. Detailed wiring diagrams including designations, tagging marks, labelling, etc, shall be submitted for approval before implementation.
- C. The number and sizes of wires and conduits indicated on the drawings are for guidance only. It is the contractors responsibility to supply and install the exact number and sizes of cables required by the equipment to be installed and to provide the right size conduits for the number of cables at no extra cost to the Owner.
- D. Each cable shall be supplied in a suitable length and be continuous through its run where adequate manufacturer lengths are available through joints will not be permitted without the permission of the Engineer.
- E. Every cable whether in or out sight shall be neatly run vertically, horizontally or parallel to adjacent walls, beams or other structural members.
- F. Cables installed in groups shall run in straight lines and not cross over each other.
- G. Cables which may be subject to accidental mechanical damage shall be suitably protected by cable guards.
- H. Where cables are surface run on the external faces of structures or above ground level, suitable protection from the radiation of the sun shall be provided by means of covers or canopies.
- I. The protection covers or canopies shall be of an approved design, securely fixed to the structure or ground and be fully ventilated.
- J. All cables shall be delivered on robust cable drums with cable ends treated to form an effective seal when a cable is cut from a drum the cable end left on the drum shall be immediately sealed in an approved manner to prevent the ingress
- K. All cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cable they are supporting. They shall be treated to withstand site conditions without corroding.
- L. Spacing of clips, saddles and cleats shall be such to prevent sagging of the cable at all times during their installed life.
- M. All power shall be connected to main switchboards and other items of plant so that the correct phase sequence and phase colour coding are preserved throughout the system. All such cables shall be identified with phase colours for 3 & 4 wire systems and blue and brown for single phase. On rotating plant

where to achieve the required direction of rotation it is not possible to connect the phase cores to the appropriately identified terminals then special core ferrules shall be fitted to identify each core with the terminal to which it is finally connected.

- N. The general routing of cables shown on the drawings is indicative the cables shall be installed as per the approved shop drawings.
- O. Cables and their support systems shall not be fixed to protective barriers, guards or directly to hand-railing.
- P. Before making of a termination, the Contractor shall ascertain whether special phasing conditions apply and shall be responsible for ensuring that all connections are correctly phased out.
- Q. The Contractor shall be responsible for obtaining drawings of all boxes or apparatus into which cables are terminated and shall ensure that the design is suitable for the use with the cables supplied under this Contract.
- R. Cables passing through floors shall be installed in the manner specified and where required shall be sealed into bushes employing fire resisting material to minimize the risk of spreading fire.
- S. In all instances where cables enter building or ducts, they shall be installed into not less than 100 mm diameter duct pipes. The ends of the pipes shall be sealed with cold plastic compound. Where cable enter below floor level the pipes will terminate in a floor recess which shall be filled with sand and covered with a thin layer of concrete, after cabling.
- T. Where cables are run within ducts, or along the surface of walls, they shall be supported by approved heavy gauge galvanized cable tray or ladder.
- U. In positions where cables rise vertically, in ducts or on the face of walls etc., they are to be fixed by means of approved cleats and spaced as recommended by the cable manufacturer.
- V. All cables shall be adequately supported and run clear of heating pipe.
- W. The wiring shall generally be carried out on the loop-in system at accessory points only. The use of junction boxes will not be permitted.
- X. Generally, all cables shall be concealed above suspended ceiling and it is intended that these shall be installed before any ceiling board is erected or plastering carried out.
- Y. Cables run in floor voids and roof space, where run parallel with the joists, shall be fixed to the joint side and where run at right angles shall be supported by cable trays. Care shall be taken to prevent the cables being subjected to

pressure or mechanical strain at bends and changes in direction. Easy bends and rounded supports shall be employed at all such positions. The inside radius of any bend is not to be less than 8 times the overall diameter of the cable.

- Z. All cables shall be prevented by spacing, insulation, or other means from coming into contact with water pipes, telephones and bell installed.
- AA. Cables run in roof space shall be laid on cable trays or ladders.
- BB. The cables shall be run and terminated otherwise as specified and as unobtrusive, neat and symmetrical as possible.
- CC. Industrial area
1. In the industrial areas like Main Workshop, Generator Halls, Main Transformer Chamber, Riser Shaft, the conduits shall be rigid metallic type surface mounted.
  2. The small power and lighting cables (Insulated only) shall be installed in conduits
  3. The Power cables (Insulated and sheathed) shall be clipped to the wall or installed on cable trays.
  4. Power cables in floor trench shall be installed on galvanized cable ladders.
- DD. Commercial area
1. In the commercial areas the conduits shall be of the non-metallic rigid type in the wall or above the suspended ceiling.
  2. The small power and lighting cables shall be installed in conduits.
  3. The power cables above the suspended ceiling shall be clipped to the wall or installed on cable trays.
  4. The power cables in the walls shall be installed in rigid non-metallic conduits embedded in walls.

### 3.02 CABLE TERMINATIONS AND JOINTS

- A. Where more than one cable is to be terminated at an item or equipment, particular care should be taken to ensure that all cables to that equipment are routed from a common direction and each is terminated in an orderly and symmetrical fashion.
- B. The Contractor shall supply and install all necessary cable glands and sealing boxes required to complete the installation. All materials used in the manufacture of the glands etc., shall have no deleterious effect on the cable core or armouring and shall not be susceptible to corrosion.
- C. The cores of each cable shall be taken direct to the terminals of the equipment to be connected. Cable ends shall be sealed in suitable chambers bolted to

terminal boxes. Compression glands with armour clamps where required are to be supplied as an integral part of switchboards, distribution boards, switches, motor starter and similar equipment unless other stated.

- D. Wherever it is necessary to remove the PVC sheath of a cable (e.g. at a joint) the minimum length necessary shall be removed and the exposed copper sheath or armouring shall be adequately covered by a PVC tape or sleeve or other suitable means.
- E. PVC or XLPE insulated cables shall be terminated with mechanical glands in accordance with BS 6121 and shall be of the type to provide adequate support to the cable by under and over locking on the cable armouring, giving a high earth continuity. Each and every mechanical cable gland shall be supplied and installed complete with brass earthing tape and a PVC gland shroud, which shall provide an effective seal on both the cable over-sheath and gland.
- F. All cable conductors shall be terminated in suitable copper lugs or brass thimbles which shall be attached to the conductors by use of a pneumatic crimping machine using the correct crimping dies for each size of cable core.
- G. Where single core glands are required, these shall be non-magnetic. The gland plate shall also be of a non magnetic material. Removable connections for bonding across the gland insulation shall be provided. The gland insulation shall withstand a test of 2 kV ac for one minute
- H. Aluminium cores of power cables shall be terminated using approved bimetallic connectors.
- I. All glands shall be provided with an earthing tag. Glands shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide mechanical support.
- J. Where cable glands are exposed to the weather, these shall be protected by heat shrink plastic tape or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.
- K. Where the apparatus enclosure classification requires sealed cable gland entries, sealing shall be achieved by using threaded cable gland holes and polytetrafluoroethylene (PTFE) tape.
- L. Multi-core or control cable terminations
  - 1. A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring and additional 20% of this number shall be provided as spares.
  - 2. Terminal blocks for terminating up to and including 35 mm<sup>2</sup> cable shall securely clamp the conductor, without damage, between two plates by means of a captive screw; pinch screw type terminal blocks

- shall not be used.
3. For cables above 35 mm<sup>2</sup>, stud or bolted terminals shall be used, each cable core being fitted with a suitable lug.
  4. Not more than one core of internal or external wiring shall be connected on any terminal. Where duplication of terminal blocks is necessary, purpose made solid links shall be incorporated in the design of the terminal blocks.
  5. Terminals which remain energized when the main equipment is isolated shall be suitable screened and labelled.
  6. Plant which has to be dismantled for maintenance shall have multi-core cable terminations made of tough glands onto an adaptable box. The box shall have terminal blocks, and connections shall be made to the equipment by single core wires and flexible waterproof plastic conduit. A separate earth core shall link the box to the equipment.

M. Joints

Through joints shall only be allowed on long cable runs outside buildings. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been pre-measured and pre-packaged ready for use. The boxed shall be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Engineer prior to filling the box with compound. Conductor cores shall be jointed number to number or colour to colour.

3.03 CABLE AND CORE IDENTIFICATION

- A. Each and every cable shall be permanently identified at each end and at entry and exit points of building's ducts by its cable number. Cable markers shall comprise oval marker with semi-rigid black PVC carrier strip and shall be fixed axially by means of two PVC covered aluminium strips with buckles.
- B. Permanent corrosion resistant identification labels shall also be installed on cables at each and every entry and exit points of buried ducts, exits and entry to any structure and in such other positions as are necessary to identify and trace the route of any site cable. The use of punch type adhesive labels (Dymo-tape) shall not be permitted.
- C. Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same numbers at both ends. Core identification shall occur at every point of termination using an approved system of ferrule markers. Numbering shall read from the terminal outwards on all cores. At those points of interconnection between wiring where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the wiring diagrams of the equipment at which the change is made.

- D. Where the termination of control cable cores or the supervision of termination of cores is specified as being the responsibility of another contractor (e.g. the termination of certain control and instrumentation cables) any necessary temporary means of core identification shall be agreed with that contractor. Should the Contractor propose to use junction boxes in auxiliary control cable circuits for the purpose of marshalling a number of cables feeding to a common item of equipment full details shall be given to the Engineer and the Contractor shall only proceed after receipt of the Engineer's written approval. Any such junction box shall be of the wall mounting pattern with double terminals with cores ferruled and identified in accordance with the system schematic and cable diagrams.
- E. All cables shall be identified below the gland at each end and at approved positions by means of bands engraved or stamped with the cable number, feeder name, size of cable, number of cores, phase colour, etc., or such lettering as the Engineer may require. The bands shall be securely fastened in a permanent manner, and shall be made of material able to resist corrosion, damp, and mechanical damage.
- F. Single core cables are to be identified by coloured tape over the cable above the gland.
- G. Tagging
1. Where two or more circuits are run to or through a control device, outlet box or ceiling junction box, each circuit shall be tagged as a guide in making connection.
  2. Conductors for which outer jacket is not coded shall either have an engraved identification mark or shall be tagged.
  3. Tags shall identify wire or cable number, conductor size and piece of equipment served in accordance with the schedules as shown on the drawings.
  4. Main and feeder cables shall be tagged in all pull boxes, wireway and wiring gutters of panels and at their terminals.
  5. All control cables and power cables shall be provided with cable markers attached to the outer sheath of the cables for ease of identification, and every cable shall be labelled with the number it is allocated on the relevant cable schedule.
  6. The cable markers shall be fitted to cables in an accessible position that is clearly readable., i.e.,
    - a. Inside a control cubicle within 100 mm of the gland position on the cable serving.
    - b. At motors, junction boxes and remote enclosures, as near as possible to the gland position.
  7. Additional marker labels shall be fitted where cables enter and leave cable tray, ducts pipes or change direction during a run.

### 3.04 SEALING

- A. Cables entering or leaving ducts shall be sealed. Power and control cables shall be sealed where they enter and leave ducts at all points and in cable chambers including intermediate pulling chambers. The sealing compound shall exhibit the following properties:
  - 1. Adheres to all metal surfaces, unplasticised, PVC, polyethylene and glazed earthenware and to cable sheath materials.
  - 2. Unaffected by water.
  - 3. Withstands at least 14 kPa (2psi) air pressure for a minimum of 15 minutes.
  - 4. Withstands up to 5 kPa (0.5 metre head) water pressure for 30 minutes.
  - 5. Self-supporting, non-setting and removable.
  - 6. Accommodates movement due to settling, subsidence or vibration.
  - 7. Vermin proof.
- B. The sealing compound shall be packed into the annulus to a depth at least equal to the diameter of the sleeve.
- C. Where the water table is identified as a problem the use of a sealing compound that adheres to wet surfaces shall be utilized.
- D. A Cable Transit System shall be used where positive sealing is required against fire, gas, or liquid. The system shall have been tested and approved by BS 476 part 20 or equivalent by the Fire Insurer's Research and Testing Organization (FIRTO) or other national testing organization.
- E. The Contractor shall be responsible for temporarily sealing all cable ducts into structures during the installation stage to prevent accidental flooding of the structures.
- F. The type of sealing systems used shall be agreed with the Purchaser and shall be selected and installed with due regard to environmental and hazardous area requirements. They shall be from one of the following:
  - 1. Approved water, gas and fire sealing transit units with fillers and insert blocks fitted to suit all cables and conduits;
  - 2. Approved oil based, non-setting, reusable sealing compound inserted into the duct or opening around all cables and conduits. Or,
  - 3. Approved fire retardant, caulking compound or fibre blocks supplied in two halves and shaped to accommodate all cables and conduits.
- G. Where a wiring system passes through elements of building construction such as floors, walls, roofs, ceilings, partitions or cavity barriers, the openings remaining after passage of the wiring system shall be sealed according to the degree of fire resistance required of the element concerned (if any).

- H. Where a wiring system such as conduit, cable ducting, cable trunking, busbar or busbar trunking penetrates elements of building construction having specified fire resistance it shall be internally sealed so as to maintain the degree of fire resistance of the respective element as well as being externally sealed to maintain the required fire resistance. A non flame propagating wiring system having a maximum internal cross-section of 710 mm<sup>2</sup> need not be internally sealed.
- I. Except for fire resistance over one hour, this regulation is satisfied if the sealing of the wiring system concerned has been type tested by the method specified in BS 476 Part 23.
- J. Each sealing arrangement shall comply with the following requirements.
  - 1. It shall be compatible with the material of the wiring system with which it is in contact and
  - 2. It shall permit thermal movement of the wiring system without reduction of the sealing quality, and
  - 3. It shall be removable without damage to existing cable where space permits future extension to be made, and
  - 4. It shall resist relevant external influences to the same degree as the wiring system with which it is used.
- K. During the erection of a wiring system temporary sealing arrangements shall be provided as appropriate.
- L. Where cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with petrolatum tape and mastic, a silicon foam or proprietary cable transits.
- M. Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes.

### 3.05 CABLE SEGREGATION

- A. Only conductors carrying signals of the same instrumentation signal category shall be contained within any one multi-core cable.
- B. In each instrumentation signal category, a further segregation is required to ensure that conductors forming part of an intrinsically safe circuit are contained within multi-core cables reserved solely for such circuits.
- C. High integrity signals such as data transmission or critical shut down signals shall be contained in separate cables.

- D. ICA/Telemetry cables sharing a cable tray, duct or route with power cables shall be avoided power cables are defined as a.c. cables above 50 volts with a 10 amp rating. Where this is not practicable, a minimum maintained separation between cables shall be provided in accordance with Table A.
- E. Where the maximum current exceeds 100 amps or the voltage exceeds 650 volts, the minimum segregation shall be 1200 mm. For higher ratings the segregation shall be progressively increased, 2000 mm from a 33 kV cable is a typical figure.
- F. Where the length of an enforced parallel run between power and ICA/Telemetry cables is greater than 500 meters, a progressive pro-rata increase in segregation distance shall apply.
- G. The segregation distances shall be maintained by positive means and shall apply to both above ground and below ground installations.
- H. Where a crossover between power and ICA/Telemetry cables is unavoidable the cable shall be arranged to cross at right angles. The number of crossovers shall be kept to a minimum.
- I. Where cable installations are of a restrictive nature such as entries into buildings, panels, etc., relation of the minimum segregation distance requirement from a power cable(s) is acceptable. The minimum segregation distance shall then be the distance, determined by the length of the parallelism at the restrictive section of the installation.

**Table A**

Distance over which parallelism exists between signal and power cables in meters		Minimum Segregation Distance Requirement in mm	
		Instrumentation Signal Classification Category to BS 6739 or equivalent	
		<b>Cat. 2</b>	<b>Cat. 3</b>
Maximum current 10 amps at any phase voltage up to 250 volts a.c. or d.c.	0 - <3	50	50
	3 - <10	100	100
	10 - <25	100	150
	25 - <100	150	200
	100 - <250	200	250
	250 - <500	250	300
Maximum current 50 amps at any phase voltage up to 650 volts a.c.	0 - <3	100	150
	3 - <10	150	200
	10 - <25	200	250
	100 - <250	275	350
	250 - <500	350	450
Maximum current 100 amps at any phase voltage up to	0 - <3	175	250
	3 - <10	200	300

650 volts a.c.	10 - <25	250	450
	100 - <250	350	525
	250 - <500	500	650

J. For the cases not considered in Clause A to I, the following shall apply.

1. Cables shall be classified into the following categories:
  - a. Band 1 (refer to BS 7671) - extra low voltage cables (signal/instrument, data transmission and telecommunication);
  - b. Band 2 (refer to BS 7671) - low voltage cables (power, control small power and lighting);
  - c. Intrinsically safe; or
  - d. HV
2. Unless otherwise specified by the cable manufacturer or for reasons of EMC or safety, the minimum between cables of different categories and other non-electrical services, shall comply with the following table:

<b>Segregation (mm)</b>	<b>Band 1</b>	<b>Band 2</b>	<b>Intrinsically Safe</b>	<b>HV</b>	<b>Other Services Above Ground</b>	<b>Other Services Below Ground</b>
<b>Band 1</b>	-	300	500	500	150	500
<b>Band 2</b>	300	-	300	300	150	500
<b>Intrinsically Safe</b>	50	300	-	500	150	500
<b>HV</b>	500	300	500	-	300	500
<b>Other Services Above Ground</b>	150	150	150	300	-	-
<b>Other Services Below Ground</b>	500	500	500	500	-	-

3. Cables of different categories shall not be installed in the same duct.
4. Public Telephone Service cables shall be installed in separate ducts.

### 3.06 CABLE IN CONDUIT

- A. All conductors to be contained within a single conduit shall be drawn in at the same time. An approved lubricant may be used in drawing conductors through conduits.
- B. A reasonable amount of slack shall be left in each conductor at distribution boards, outlets boxes and other devices to facilitate the making of joints and connections to fixtures and equipment.
- C. Branch circuits shall be properly balanced on the buses of distribution boards.

- D. Single core cable shall be drawn into conduit or trunking with multi-core cables laid on trays or run on surfaces to which they are affixed as a continuous length between points of termination. The use of junction boxes will only be permitted with the written approval of the Engineer.
- E. Single core cables run in conduit or trunking shall be limited in the number contained in each conduit or trunking in accordance with the grouping allowed in calculating their current rating and the maximum containment in accordance with BS 7671.
- F. Circuits supplied from different distribution boards shall not be installed in the same conduit.
- G. Final sub circuits shall not be installed in the same conduit as sub mains circuit.
- H. DC circuits shall be run in separate conduits.

### 3.07 CABLES ON LADDERS/TRAYS

- A. Cables shall be supported to avoid damage during installation, prior to dressing and fixing.
- B. Cables shall be securely fixed to ladder/trays
- C. For cables installed in accessible positions, where the entire support for the cable is derived from clips, the maximum spacing of clips shall comply with IEE Guidance Note No.1: Selection and Erection, Appendix 1.
- D. Depending on their overall diameters, single cables and groups of cables shall be secured according to the applicable standard.
- E. In outdoor locations, where installation could be subject to ultra violet light, PVC covered aluminium tape shall be used in preference to nylon cable ties.
- F. Cables installed in groups shall be installed in straight lines and not cross over each other. Cables shall not be installed in more than two layers, comprising a maximum group size of 7.
- G. Where cables leave trays shall be covered with PVC or formed to present a smooth surface to prevent damage to the cable.
- H. Single core power cables shall be secured throughout using proprietary trefoil cable cleats.

### 3.08 CABLES IN TRUNKING

- A. In order to prevent damage to cables during installation, cables shall not be

installed into any section of trunking until that section has been completed.

- B. The trunking shall provide 10% spare rated capacity.
- C. Cables of individual circuits shall be taped together, at 1500 mm intervals, along their length to avoid damage to cables in trunking mounted other than lid up and particularly in all vertical runs and at bends, proprietary cable retainers/supports/pin racks/cable guides shall be used.
- D. Trunking shall be terminated using proprietary fittings.

### 3.09 MINERAL INSULATED COPPER CABLE INSTALLATION:

- A. Where MICC cables are run on the surface, they shall be fixed by single or multiway heavy gauge copper saddles at 1 meter intervals and in damp or dusty situations shall be spaced from the surface by means of spacebar saddles. The saddles, of an approved type, shall be affixed by means of brass screws and fixings, and shall be PVC sheathed with PVC covered MICC cables.
- B. Where possible all MICC cables shall be concealed by making use of floor or ceiling spaces or by burying them in the plaster of the walls and ceilings. All runs must be vertical in walls. Where MICC cables are recessed in plaster walls or concrete or similar then these are to be PVC sheathed. No type of MICC installation shall be permitted in floor screeds or cast in situ concrete.
- C. Under no circumstances will MICC cables be run inside metal conduits.
- D. Under no circumstances will through joints be allowed in underground MICC cables and joints will only be permitted in the MICC cables installed in buildings on instruction from the Engineer.
- E. All MICC cable terminations shall be made with screw on pot seals using cold plastic compound and plastic sleeving, all of an approved pattern. Where applicable heat shrink type seals may be used on instruction from the Engineer.
- F. Universal ring type glands only shall be used where cable enters joint boxes or apparatus. Flame proof Exd or Eexd type shall be used in relevant locations.
- G. All MICC cable seals shall be tested not less than twenty-four hours after completion. The test shall be applied to all conductors with insulation testing equipment of the Megger type at 500V or 1000V and nothing less than a reading of infinity shall be obtained between the conductors or between any conductors and the cable sheath, the conductors being disconnected from any apparatus.
- H. All cable terminations shall conform to standard colour coding.

- I. Where cable terminates at motors or other equipment that vibrates, a suitable anti-vibration coil shall be provided adjacent to the termination.
- J. Where single core cables are used, the induced circulating currents shall be minimized by keeping the sheathed loop circuit electrically open at one end of the cable (i.e. the equipment entry plate at the outer end shall be brass to avoid eddy currents).
- K. The radius of bend shall not be less than six times the diameter of the cable employed except with the written approval of the Engineer.
- L. Under no circumstances shall plain MICC cable to run on galvanised cable trays. In all such instances MICC cables shall be PVC served overall. All saddles shall be PVC served where used in conjunction with MICC/PVC cables.
- M. When MICC cabling is run on cable trays then these shall be clipped to cable trays at intervals not exceeding 300 mm for horizontal runs and not exceeding 150 mm for vertical runs, by means of copper saddles, plain copper or PVC served overall, as appropriate. All securing nuts and screws shall be machined brass with minimum size of M4 or equivalent.

### 3.10 CABLES TRENCH WORK

- A. Cables Routes: The Contractor shall prepare drawings to scale showing the cables routes and method of installation. He shall draw up diagrams indicating sizes and types. These drawings shall be submitted to the Engineer.
- B. The arrangement of the cables and all methods of laying shall be approved by the Engineer and shall be planned to provide an orderly formation, free from unnecessary bends and crossing, which will permit the removal of any one cable without undue disturbance to adjacent cables. No joints shall be allowed in any cable unless approved by the Engineer.
- C. The proposed trench route shall be surveyed for the presence of underground cables and/or services before digging commences.
- D. Machine digging shall not be permitted within 1 m of suspected cable positions.
- E. Lines of trenches shall be kept as straight as possible.
- F. Trenches shall have vertical sides supported to avoid subsidence. Where a change in ground level is necessary, the bottom of the trench shall rise or fall gradually.
- G. To ensure that trench bottoms are firm, smooth and free of loose stones and

debris, they shall be lined with approximately 200 mm of sand or other approved material.

- H. The trench backfill shall be compacted in layers of a maximum thickness of 200 mm and the surface reinstated to a condition not inferior to that of the surrounding ground.
- I. When excavations for trenches have been accurately executed, notice shall be given by the Contractor to the Engineer. Laying of cables or building of structures shall not be started until the Contractor has obtained the Engineer's sanction to proceed with the work.

### 3.11 INSTALLATION OF DIRECT BURIED CABLES

- A. The excavation and backfilling of cable trench work shall be carried out by the Contractor.
- B. The Contractor shall supply and lay the sand bedding, cables, sand blinding, cable cover tiles and marking tape. He shall also supply and lay cable route marker posts after the backfilling and top soiling, has been carried out.
- C. The sanding and laying of all cables shall satisfy the following requirements:
  - 1. Cable depths shall be assessed from the finished ground level unless otherwise directed by the Engineer.
  - 2. H.V. cables shall be laid at a depth of 1 meter.
  - 3. L.V. cables shall be laid at a depth of 0.6 meter.
  - 4. H.V. and L.V. cables may be run in the same trench but should be staggered. However where necessary to pass through ductwork, cables shall be laid vertically above each other with the H.V. cables at the lowest level with a good sand blinding forming the sand bedding for the L.V. cables.
  - 5. Before laying in cables the Contractor shall inspect the trench work to ensure that the trench bottom is of a smooth and firm contour and free from all sharp materials or obstructions.
  - 6. Cable bedding within the trenches shall be formed by a 200 mm sand layer.
  - 7. Cables shall be laid with adequate separation and shall be <<snaked>> to avoid tension during backfilling operations and subsequent settlement.
  - 8. Before sanding and backfilling, all laid cables shall be inspected by the Engineer, and a further inspection following sanding and tiling shall be made by the Engineer before backfilling.
  - 9. After cables have been laid, they shall be covered by a further 200 mm of sand which shall be well tamped around the cables. Mechanical pruners shall not be used for this work.
  - 10. After sanding cable cover reinforced concrete tile inscribed "ELECTRIC CABLE" shall be of adequate width to ensure an overlap

of 150 mm on each side of the cable or group of cables protected. Where two or more tiles are required to protect a group of cables, the longitudinal joint between adjacent tile shall be at least 50 mm from the nearest cable.

11. A bright yellow or orange coloured plastic tape 150 mm wide by 0.1 mm thick shall be laid in a continuous manner above the center of each 300 mm width of trench, 150 mm below ground level. The tape shall be continuously indelibly marked English with the words.

**DANGER ELECTRIC CABLE**

12. Care shall be taken to ensure complete continuity of such tape, and care taken to avoid displacement of the tape during backfilling.
13. Cables shall be unrolled from the drums in such a manner as to avoid loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp obstacles or stones.
14. Where cable of different voltage are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.
15. Control and communication cables shall be laid not closer than 300mm to any high voltage cables.
16. The Contractor shall carry out backfilling and shall ensure that cable cover tiles are undisturbed and that large rocks, stones and the like are eliminated from backfill spoil.
17. After backfilling the Contractor shall reinstate to finished ground level. The Contractor shall lay in position the necessary cable route markers at a maximum of 10 meters apart and at any change in direction.
18. The Contractor shall be solely responsible for ascertaining whether the soil is chemically active and for ensuring that the cables and accessories are suitable for the conditions prevailing on Site and for taking special precautions to protect the cables against chemical action.
19. A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.
20. All direct buried cables shall be provided with a sheathing material which shall not be degraded by the presence of salt or other minerals in the ground water in which they may be installed. The Contractor shall be responsible for determining the ground conditions for all externally installed cables.
21. Cables shall be installed in ducts where trenches pass under roads, paved area and foundations.
22. The open ends of all cable ducts (included unused ducts) and openings in building structures specifically provided for the passage of cables (including unused openings) shall be sealed after cable installation to prevent the ingress of harmful or flammable gases, liquid, smoke, fire and vermin.

### 3.12 CABLES INSTALLATIONS IN TROUGHS

- A. Where the building structure incorporates purpose built covered trench systems cables shall run on cable trays secured to the trench wall or brackets.

- B. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.
- C. Where the building structure incorporates general service trenches containing pipework, chemical lines and other services all cabling shall be segregated from other services and run on the trench walls. Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipe works.

### 3.13 INSTALLATION OF CABLES IN UNDERGROUND DUCTS

- A. Types of Ducts:
  - 1. Rigid ducting shall consist of:
    - a. Unplastiscised PVC pipework complying with BS EN 50086-2-4; or
    - b. Vitrified fireclay pipework.
  - 2. Rigid ducting shall have proprietary, self aligning, water tight joints and a smooth bore.
- B. Installation of Ducts
  - 1. Sufficient ducts shall be installed to provide a spare capacity of 20%. Under roadways carrying vehicular traffic, sufficient ducts shall be installed to provide a spare capacity of 50%, subject to a minimum of 2 ducts.
  - 2. All joints and changes in direction of the duct system shall be achieved by the use of proprietary bends and accessories made of the same material as the duct.
  - 3. The maximum length of a straight duct run (between draw-pits) shall be 100 m. This length shall be reduced 1 m per degree of bend up to a maximum of 90 degrees. the maximum angle of a single bend in a duct run shall be either:
    - a. 45.0' where all cables have a diameter less than 35 mm; or
    - b. 22.5' where any cable has a diameter greater than 35 mm.All bends shall be the long radius type.
  - 4. Ducts shall be installed at 90' under roadways carrying vehicular traffic and shall be haunched in concrete to prevent damage. There shall be a minimum of 750 mm of cover above the crown of the duct and the duct shall be extended beyond kerbs by a minimum of 750mm.
  - 5. Ducts carrying cables of different segregation categories shall be spaced in accordance with clause 3.05.
  - 6. Ducts shall be laid on and surrounded by a backfill material which will not cause damage to the duct.
  - 7. Depth of cover in soft ground shall be a minimum of 500 mm above

- the crown of the duct.
- 8. All duct trenches shall be backfilled immediately after duct laying.
- 9. Ducts passing through floors shall terminate approximately 75 mm proud of the surface of the floor.
- 10. On completion, all duct runs shall have a swab drawn through to clear them of obstructions.
- 11. Ducts shall be left with an excess 1 m length of 8 mm diameter nylon drawcord in place, anchored at each end.

C. Draw-pits

The following shall apply:

- 1. The minimum size of draw-pits shall be 750 mm square;
- 2. Where draw-pit covers cannot be removed safely by one person, mechanical lifting equipment shall be provided.
- 3. If possible, draw-pits shall be provided with suitable drainage;
- 4. The sizing of draw-pits shall facilitate cable installation and maintain the required cable segregations without contravening the minimum bending radii of the cable; and
- 5. Draw-pits installed under roadways carrying vehicular traffic shall be fit for purpose.

D. Installation of Cables into Ducts

- 1. Where draw cords are used to pull cables through ducts, a replacement draw cord shall be drawn through with the cables.
- 2. Proprietary pulling socks shall be used to attach a draw line to larger cables and care shall be taken to ensure that cable tensions are maintained below cable manufacturer's specifications.
- 3. Where practicable, cables shall be pulled directly off the drum into the duct system. They shall not contain twists or kinks resulting from manual handling. where any cable exits a duct, it shall be supported between the duct exit and the start of the fixed wiring support system or entry into another duct.
- 4. Rollers shall be positioned at the edges of draw-pits both at the drawing in and drawing out points over which the cables shall be drawn.
- 5. uPVC pipes and cable sheaths shall be coated with an approved lubricant.
- 6. Sufficient draw-in points shall be provided and adequate room allowed for installation of cables.
- 7. The pulling rope shall be guided by rollers.
- 8. Measures shall be employed to ensure that the manufacturer's recommended maximum pulling force is not exceeded for the cable being installed.

9. Only one power cable shall be drawn into one duct, unless otherwise approved by the Engineer.
10. Whenever a duct is laid in the ground, a draw wire shall be pulled through with at least 1000 mm excess at each end and the draw wire left if the duct is not to be used immediately.
11. Where single core cable are individually drawn into separate pipes, non-metallic pipes shall be used.
12. At situations where buried cables cross other cables, a suitable arrangement of ducts encased in concrete or a formed concrete trench shall be provided to effect the crossing and to facilitate the removal of one cable without disturbing the others.

### 3.14 MARKING OF UNDERGROUND CABLES

- A. The location of all underground cables shall be identified by:
  - (1) Brass plates fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.
  - (2) Marker posts on road verges, etc, at intervals of not more than 100 m and at all junctions and changes of direction along the route;
  - (3) Marker posts at 10 m intervals within an enclosed site and at all junctions and changes of direction along the route.
- B. Marker posts shall be of concrete, not less than 200 mm high with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of cable below, the depth and voltage rating.
- C. A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer.

**\*\*END OF SECTION\*\***

**SECTION 16141**  
**WIRING DEVICES**

**PART 1 - GENERAL**

**1.01                      DESCRIPTION**

- A. The work to be performed includes, but is not necessarily limited to, all work involved with the supply and installation, connection and testing of switches, socket outlets, telephone and computer outlets, remote control station as shown on the drawings and as per the requirements of this section.
- B. The types of electrical wiring devices specified in this section include the following:
  - 1. Lighting Switches.
  - 2. Push Buttons
  - 3. Double Pole Switches.
  - 4. Triple-Pole and Neutral Switches.
  - 5. Switches, Disconnect, Switch -Disconnect and Fuse - Combination
  - 6. Socket Outlets.
  - 7. Industrial Type Socket Outlets.
  - 8. Fused Connection on Units
  - 9. Shaver Supply Unit
  - 10. Remote Control Station
  - 11. Telephone Outlet
  - 12. Computer Outlet.

**1.02                      QUALITY ASSURANCE**

- A. The Contractor is responsible for the quality of all purchased items and as such, must develop and submit a supplier quality inspection plan for review. The inspection plan is to cover those items intended for shop inspection and the procedures for carrying out same.
- B. Manufacturer: Wiring devices shall be the standard products of manufacturer regularly engaged in manufacture of wiring devices of the types

and ratings required and complying with the requirements of the listed standards and whose products have been in satisfactory use in similar service for not less than 5 years.

C. Codes and Standards: Comply with requirements of latest edition of the following codes and standards except as herein modified.

1. BSI - British Standard Institution:

BS 1362	Specification for general purpose fuse links for domestic and similar purposes (primarily for use in plugs).
BS 1363	13A plugs, socket-outlets and adaptors.
BS 3676	Switches for household and similar fixed installations.
BS 4177	Specification for cooker control units.
BS 4343	Specification for industrial plugs, socket outlets and couplers for AC and DC supplies.
BS 4662	Boxes for the enclosure of electrical accessories.
BS 5345	Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmosphere.
BS 5733	Specification for general requirements for electrical accessories.
BS 6220	Specification for junction boxes for use in electrical installations with rated voltages not exceeding 250V.
BS 7671	Requirements for electrical installations.
BSEN 60309	Plugs, socket-outlets and couplers for industrial purposes.
BSEN 60947	Specification for low voltage switch gear and control gear.
	Part 3 Switches, disconnectors, and fuse combination units.

2. IEC - International Electrotechnical Commission.

IEC 60079	Electrical apparatus for explosive gas atmospheres.
IEC 60083	Plugs and socket outlets for domestic and similar general use standards.
IEC 60309	Plugs, socket outlets and couplers for industrial purposes.
IEC 60364	Electrical installation of buildings.
IEC 60669	Switches for household and similar fixed electrical installations.
IEC 60670	General requirements for enclosures for accessories for household and similar fixed electrical installations.
IEC 60884	Plugs and socket outlets for household and similar purposes.
IEC 60906	IEC system of plugs and socket outlets for household and similar purposes.
IEC 60947	Low voltage switchgear and control gear.
	Part 3 - Switches, disconnectors, switch - disconnectors and fuse combination units.

1.03

TESTS AND ACCEPTANCE CRITERIA

- A. Unless requirement is waived wiring equipment shall be tested as per listed standards and manufacturer's test reports certifying that devices meet the requirements of the listed standards submitted.

1.04

SUBMITTALS

- A. The Contractor shall submit to the Engineer the required documents to establish compliance with this section. Submittal shall include at least the following.
1. Manufacturer's Data: Including specifications, installation instructions, dimensions and general recommendations for each type of wiring devices.

2. Shop Drawings: Dimensioned drawings showing accurately scaled layouts of the location of the wiring devices and their spatial relationship to associated equipment.
3. As built drawings
4. Test certificate.

## PART 2 - PRODUCTS

### 2.01 LIGHTING SWITCHES

#### A. General:

1. Lighting switches shall be to IEC 60669/BS 3676.
  2. Switches shall be rated 15/20 amps and shall not have to be derated when used with fluorescent and inductive loads.
  3. Switch terminal shall each be capable of terminating two (2) – 2.5 sq. mm solid conductors as minimum.
4. An earth terminal shall be provided at every lighting switch box
5. Switches shall be of the flush type for concealed installation and of the surface type for exposed installation.
6. Switches shall be mounted in galvanized steel box to BS4662 for flush box and to BS5733 for surface box.
7. Where it is unavoidable to bring more than one phase into say a multi-gang switch box, then warning notices must be displayed on the grid plate or on the reverse of the switchplate “danger presence of 380 volts” and a plate divider provided.

#### B. Switches for indoor use:

1. Switches for internal use shall generally have an insulated white finish cover plate except in prestigious areas where brass or matt chrome finish shall be employed. Surface mounted switches shall have metal clad plate with steel finished box.
2. The dolly or rocker shall be insulated.
3. Switches for indoor use shall be of the grid mounting pattern to suit the required circuit arrangement.
4. Where more than one switch is indicated in a position, these shall be

ganged in the same box and a multi-gang switchplate used.

C. Switches for outdoor use:

1. Switches for external use shall be protected to IP54, surface mounted and enclosed in fibre glass reinforced plastic or metal boxes.

2.02 PUSH BUTTONS

- A. Provide ON/OFF push buttons for lighting control to locations indicated on drawings and in FDB schedules.
- B. ON/OFF push buttons shall be of switch type.
- C. Rating of push buttons shall be of minimum 5A, 230 V AC (only for control voltage).
- D. Operating mechanism to be contained in the device box.
- E. Where two or more ON/OFF buttons occur in one position they shall be contained in one case and each shall be appropriately labelled to indicate its function.
- F. Material and finish of push buttons shall generally have an insulated white finish cover plate except in prestigious areas where brass or matt chrome finish shall be employed. Surface mounted push buttons shall have metal clad plate with steel finish box.

2.03 DOUBLE POLE SWITCHES

- A. Double pole switches shall conform to the requirements of IEC 60669/BS 3676 where used for the connection of fixed appliances.
- B. Switches shall be suitable for use at a system voltage of 230 volts minimum and shall be continuously rated at 20, 32, 45 amps, or as shown on the drawings or specified elsewhere. Switches shall be of the following types:
  - Double pole switch.
  - Double pole switch with indicator light.
  - Double pole switch with cord outlet facility.
- C. Where switches are specifically used for a water heater or cooker the face plate shall be engraved accordingly.
- D. All units shall be of similar style and finish to those specified for lighting switches and socket outlets.
- E. Switches shall be of flush type for concealed/embedded installation and of the

surface type for exposed installation.

- F. Primary connection terminals shall be capable of receiving and satisfactorily connecting the conductors shown on the drawings.
- G. Contact pressure with the conductors shall preferably be by clamp plate rather than pinch screw.
- H. Switches shall be mounted in galvanised steel boxes with conduit entries and of minimum internal depth of 35 mm.
- I. All switches and their enclosures shall be provided with terminals as necessary to allow connection of circuit protective conductors in accordance with the requirements of listed Standards.
- J. Where cord outlet facilities are included a cable clamp shall be provided to secure the outgoing cord or flexible cable.

2.04 TRIPLE POLE AND NEUTRAL SWITCHES

- A. Triple pole and neutral switch shall be to IEC 60947-3/BSEN 60947 Part 3.
- B. Switches shall be suitable for use at a system voltage of 400V and shall be rated as shown on drawings.
- C. The utilisation category of the switch shall be AC22A.
- D. Switches shall be similar style and finish to those specified for lighting switches and socket outlets.
- E. Switches shall be fitted with earth terminals and indicating light.
- F. Box shall be steel made to BS 5733.

2.05 SWITCHES, DISCONNECTORS, SWITCH -DISCONNECTORS  
AND FUSE COMBINATION

- A. The switch device shall comply to IEC 60947-3/BSEN 60947: Part 3 and shall be suitable for uninterrupted duty.
- B. Switching devices shall be suitable for isolation and shall be to over-voltage category IV to IEC 60947-1/BSEN 60947 : Part 1
- C. Unless otherwise specified the utilization category for switching devices shall be AC 23.
- D. The operating mechanisms shall be of the independent manual type with provision for locking in the OFF position and shall be interlocked with the access door.

- E. The switching device shall be 3P, 6P, SP&N or TP&N as shown in the drawings and as required.
- F. Separately mounted switches shall be housed in high impact carbonate enclosures protected to IP 54 unless otherwise indicated.
- G. The switching devices shall be air break quick make, quick break with a front operating handle with ON/OFF indication.
- H. Fuse links for use in fuse - combination unit shall comply with IEC 60269/BS 88.

2.06                      SOCKET OUTLETS

- A. Switch socket outlets for general service shall be of the three pin (two pole and earth) type and unless otherwise specified, shall be two gang. Socket outlets shall be rated 250V 13 amps unless otherwise indicated.
- B. Socket outlets rated at 13 amps, shall employ rectangular pins; shall conform to BS 1363, and shall be fitted with an integral fuse complying with BS 1362.
- C. Outlets for internal use shall generally be of the insulated pattern white finish, except in prestigious areas where brass or matt-chrome finish shall be employed. For surface mounted installation metal clad enclosures and finishes shall be used.
- D. Outlets for exterior use shall be protected to IP54 and shall be pattern enclosed in glass reinforced plastic or galvanised metal boxes.
- E. Terminals shall be complete with captive washers. Terminals for 230 volt outlets shall each be capable of receiving and satisfactorily connecting the indicated conductors.
- F. Contact pressure with the conductors shall preferably be by clamp plate rather than by pinch screw.
- G. All socket outlets for flush fitting shall be mounted in the appropriate recessed metal box.
- H. Socket outlets and their enclosures shall be complete with all necessary terminals for the connection of circuit protective conductors as required by the listed Standards
- I. All boxes providing enclosure and/or mounting for socket outlets shall be galvanised steel complete with conduit entries unless otherwise specified.
- J. The Contractor shall supply one plug top for each socket outlet installed and shall allow to connect all portable appliances for which a plug and socket

connection is appropriate.

- K. Unused plugs shall be handed to the Engineer on completion of the works and a receipt received for same.
- L. Socket outlets for non-standard supplies shall have a non-standard pin configuration and for hazardous areas shall conform to BASEEFA or NFPA requirements as appropriate or as specified elsewhere. Socket outlets in these categories shall generally be surface or flush mounted in metal boxes complete with conduit entry facilities. The standard of enclosure and housing and the addition of an interlocked integral switch shall be selected according to use.
- M. Terminals shall each be capable of accepting a minimum of two conductors each conductor of current rating equal to the socket outlet rating, after taking into account derating of cables for ambient temperature and cable grouping.

2.07

#### INDUSTRIAL TYPE SOCKET OUTLETS

- A. Industrial type socket outlets shall be heavy duty type, to IEC 60309/BS 4343 and shall be used where shown on drawings. These outlets can be used in humid or wet areas, where they have a minimum ingress protection of IP44 or IP67 in accordance with IEC 60529. They shall be colour coded to suite the voltage range of their intended use. Industrial socket outlets shall be supplied with a matching plug top. Ratings and pin configuration shall be as indicated on the drawings. The housing shall be made of polycarbonate. The socket outlet shall be surface mounted and if indicated switch interlocked. They shall have a pilot contact.

2.08

#### FUSED CONNECTION UNITS

- A. Provide fused connection units as shown on drawings and as indicated in FDB schedules.
- B. Connection units shall be of unswitched type with flex-outlet and pilot lamp.
- C. Connection units shall be fitted with an earth terminal and fuse carrier.
- D. Fuse carrier shall be fitted with 13 A fuses.
- E. Connection units shall be flush mounted type.
- F. Material and finish shall be as approved by the engineer.

2.09

#### SHAVER SUPPLY UNIT

- A. Provide dual voltage shaver supply unit to locations indicated on drawings and in FDB schedules.
- B. Shaver supply units shall be fitted with double wound isolating transformers, input 230 Volt AC, output 20 VA at 230 or 115 volts AC.
- C. Insertion of a shaver plug shall automatically switches on by energizing the primary side of the plug shall switch it off.
- D. The transformer shall be protected against overload by an automatic solid state overload device with automatic resetting.
- F. The sockets shall be shuttered and shall be operated only by inserting both pins simultaneously.
- G. All shaver supply units shall be finish mounted type and having material and finish matching and finish interior finish and as approved by the engineer.

2.10                      REMOTE CONTROL STATION

- A. The Contractor shall provide and install emergency remote control station consisting of mushroom headed red stay-put type pushbuttons for the purposes of emergency stopping of all items of plant and machinery. The number and location of each push-button must be approved by the Engineer for each drive and where the requirement for a particular machine is waived written permission must be obtained.
- B. Each push-button shall be housed in a surface mounting IP54 enclosure and shall be identified by the surrounding circular escutcheon plate forming a black ring on a yellow background and shall be mounted as shown on the drawings.

2.11                      TELEPHONE OUTLET, CORD OUTLET AND COMPUTER OUTLET PLATES

- A. All outlet plates where specified shall be of similar style and finish to that specified for the associated lighting switches and socket outlets and shall be suitable for mounting on a galvanised steel box with conduit entry facilities.
- B. Unless otherwise specified telephone outlet plates shall be complete with a plug and socket outlet.
- C. Cord outlet plates shall be complete with a 3-way terminal block (each terminal) suitable for termination of three (3) - 2.5 sq mm or two (2) - 4 sq mm incoming solid conductor cables and one (1) outgoing 3 c - 2.5 sq mm flexible cable and with a cable clamp to secure the outgoing cord or flexible cable unless otherwise noted.

- D. Computer terminal outlet shall be similar to the telephone outlet with plug and socket outlet.

### PART 3 - EXECUTION

#### 3.01 INSPECTION

- A. Contractor must examine substrates and conditions under which work will be carried out and correct any unsatisfactory conditions. Do not proceed with work until all unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

#### 3.02 INSTALLATION

- A. Installation of wiring devices shall not be done until wiring is completed.
- B. Wiring devices shall be installed in electrical boxes which are clean and free from excess building materials, debris, etc.
- C. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or non-standard methods.
- D. Plates installed in wet locations shall be gasketed and duly protected. Where not indicated mounting heights of outlets shall be as required by the Engineer. The heights shall be measured from finished floor to center of outlet.
- E. Wiring devices shall be positioned consistently throughout the installations such that the order from left to right and top to bottom arrangement of outlets have the same relationship.
- F. All lighting switch plates shall be set square to the vertical and horizontal axis and where flush pattern lighting switches are wall mounted on tiles, timber cladding or fair faced blockwork then special care must be taken to ensure that the final position of all switch/socket plates are set symmetrical with pattern of the wall finishes required by the Engineer.
- G. In all cases where lighting switches, socket outlets and other accessories are within two (2) meters adjacent position of each other they should without exception be wired on the same phase.
- H. Unless otherwise stated, all accessories shall be mounted in or on a steel conduit box with conduit entry facilities.
- I. Conduit boxes for flush mounting accessories and for use in all galvanized conduit installations shall be galvanised finish.
- J. All conduit boxes shall be complete with brass earthing terminals as necessary

to allow fully compliances with listed Standards.

- K. Unless otherwise specified accessories shall be mounted at the following heights above finished floor level to centre:

Lighting Switches 1350 mm

Socket Outlets  
(Domestic & Office Accommodation) 450 mm

Socket Outlets  
(above worktops, in wet & workshop areas) 1200 mm

Spur Units, DP and TP&N Switches,  
Door Bell Pushes 1100 mm

Fire Alarm Break Glass Units 1400 mm

Wall Mounted Luminaires 1800 mm  
Fire Alarm Sounders, Wall Mounted  
Loud Speakers, Fire Alarm Panels,  
Distribution Boards and Isolators  
to Top Face 1850 mm

Overdoor Luminaires 2000 mm

- L. Accessories within one area shall be arranged and aligned neatly at the heights specified other than where it is necessary to site an accessory adjacent to the equipment it serves (e.g. Cord outlet connections to High Level Fans, Heaters, etc., where a revised mounting height of 1800 mm may be more appropriate).
- M. Accessories mounted in floor outlet boxes shall only be fitted to the mounting plate or tray provided by the manufacturer. The mounting plate or tray shall be pre-punched to suit the accessories to be fitted.
- N. Drilling, cutting and fabrication of mountings on site will not be accepted.
- O. Accessories shall only be mounted in the section of floor outlet box appropriate to the services for which they are intended.

\*\* END OF SECTION \*\*

## **SECTION 16163**

### **DISTRIBUTION BOARDS**

#### **PART 1 - GENERAL**

##### **1.01                      DESCRIPTION**

- A. The work to be performed includes, but is not necessarily limited to, all work involved in the supply and installation of distribution boards as indicated on the drawings and as by the requirements of this Section.
- B. The types of distribution boards and accessories specified in this section include the following:
  - 1. Final Distribution Board
  - 2. Submain Distribution Board
  - 3. Main Distribution Board

##### **1.02                      QUALITY ASSURANCE**

- A. The Contractor is responsible for the quality of all its purchased items and as such, must develop and submit a Supplier Quality Inspection plan for review. The inspection plan shall cover those items intended for shop inspection and the procedures for carrying out same.
- B. Manufacturer: Final, Submain and Main Distribution boards shall be the standard products of a manufacturer regularly engaged in manufacture of such equipment and complying with the requirements of the listed standards and whose products have been in satisfactory use in similar service for not less than 5 years.
- C. Codes and Standards: Comply with the requirements of latest edition of the following codes and standards except as herein modified.
  - 1. BSI                      British Standard Institution:
    - BS 4293                  Specification for residual current operated circuit breakers.
    - BS 5486                  Low-voltage switchgear and control gear assemblies.
    - BSEN 60439              Specification for low voltage switchgear and controlgear assemblies.

BSEN 60898 Specification for circuit breakers for over current protection for household and similar installation.

BSEN 60947 Specification for low voltage switchgear and control gear.

BSEN 61008 Residual current operated circuit breakers, without integral over-current protection for household and similar uses (RCCB's).

BSEN 61009 Residual current operated circuit breakers with integral over-current protection for household and similar uses (RCBO's).

2. IEC International Electrotechnical Commission.

IEC 60439 Low voltage switchgear and controlgear assemblies.

IEC 60755 General requirements for residual current operated protection devices.

IEC 60898 Electrical accessories circuit breaker for over-current protection for household and similar installations.

IEC 60947 Low voltage switchgear and controlgear.

IEC 61008 Residual current operated circuit breakers without integral over-current protection for household and similar uses (RCCB's)

IEC 61009 Residual current operated circuit breaker with integral over-current protection for household and similar uses (RCBO's).

#### 1.03 TESTS AND ACCEPTANCE CRITERIA

- A. Material Test: Unless requirement is waived in writing, submit to the Engineer two copies of manufacturer's test reports certifying that materials meet specified standards.

#### 1.04 SUBMITTALS

- A. The Contractors shall submit to the Engineer the required documents to establish compliance with this section. Submittals shall include at least the following:

1. Manufacturer's data including specifications, installation instructions and general recommendations for each type of distribution board required. Include data substantiating that units comply with requirements.
- B. Shop drawings, single line diagram, schedule of points and dimensioned drawings of distribution boards and enclosures showing accurately scaled layouts of enclosures and required individual board devices, including but not necessarily limited to circuit breakers, residual current circuit breaker, disconnect.
- C. Test certificates.

## PART 2 - PRODUCTS

### 2.01 DISTRIBUTION BOARDS

1. Distribution boards shall be of the totally enclosed metal clad pattern manufactured to IEC 60439/BS 5486 standards unless otherwise specified.
2. The enclosures shall generally be suitable for surface or recessed wall mounting and shall be provided with conduit and cable gland entry plates and with a hinged and lockable door.
  3. The enclosure shall be made from zinc coated sheet steel of minimum thickness of 1.5 mm.
  4. The distribution board shall be provided with fixed cover and a hinged door with lockable handle which can be opened without any obstruction about 120 degrees and conduit knock outs from the top and bottom. The hinged door can be an integral part of the fixed cover.
5. The steel enclosure shall be protected to IP 54.
  6. Each distribution board shall be arranged for top and bottom cable entry and shall be provided with an ample cable termination plate and chamber to enable cables to be neatly glanded with tails grouped and terminated onto appropriate internal terminations. Distribution boards shall be wall or floor mounted and shall when specified incorporate onload isolators which shall be front of panel operated with ON/OFF indicator and capable of being padlocked in the OFF position. Distribution boards shall incorporate combination of single pole and triple pole circuit breakers shown on the drawings and schedule of points.

7. The termination of the circuit cables at distribution boards shall be neat and slack left at each circuit breaker or neutral bar to enable the complete assembly to be removed for inspection without disconnection. Neutral conductors shall be connected to the bar in the same order as the phase conductor to the circuit breaker.

8. Each distribution board shall be complete with a permanent circuit identification chart preferably counted within the front door. This chart shall be permanently and legibly filled in as circuits are complete with the circuit description including the breaker rating.

9. Painting of distribution boards shall be in approved colours.

10. The boards shall be properly earthed by connecting an earthing conductor from main distribution earth bar to an earth connector welded to the cabinet.

#### B. Final Distribution Board

1. The arrangement of the enclosure shall be such that the switch, MCB, RCCB and RCBO cannot be operated without opening the hinged doors. To obtain access to MCB, RCCB and RCBO it should be necessary to remove the fixed cover.
2. For final distribution board miniature circuit breakers may be used, unless otherwise specified.
3. The final distribution boards shall be controlled by an adequately rated ON load disconnecter to interrupt the supply to the entire distribution board unless otherwise indicated on the drawings.
4. The arrangement of the MCB in the triple pole distribution board shall allow replacing a triple pole MCB with three adjacent single pole MCB's and vice versa.
5. The directory of the circuit to be kept in a plastic pouch affixed to the inside of the hinged door.
6. It should be possible to install RCCB or RCBO for each branch.
7. Distribution boards shall be single phase and neutral or three phase and neutral. Neutral connections shall be provided in number equal to the number of single phase ways.

8. Distribution boards shall be of the fully shrouded pattern to prevent accidental contact with live parts.
9. Distribution boards employing miniature circuit breakers shall be capable of accepting breakers of mixed ratings and of standard or residual current detection type.
10. Distribution boards shall be provided with an earth bar to allow connection of circuit protective conductors. The number of connections shall be equal to the number of single phase ways. A main earth terminal shall be provided to allow bonding of the enclosure in accordance with the requirements of the listed Standards.

Such an earth terminal shall also be provided on the local disconnect enclosure where this forms a separate unit to the distribution board.

11. Neutral bar shall have a separate terminal for each breaker.

## 2.02

### MAIN AND SUBMAIN DISTRIBUTION BOARD (MDB and SMDB)

- A. Construction: The MDB and SMDB shall be one cubicle type with a vertical bus bar in the middle of the board. The outgoing circuit breaker shall be mounted horizontally. A separate front plate shall be provided so that no live part may be touched. The board shall be provided with hinged door with lockable handle.
- B. Bus Bar:
  1. Main and auxiliary busbars shall be electrolytic copper with 99.9% purity.
  2. All busbar connections and joints shall be either silver plated or tin plated.
  3. A neutral busbar shall be provided having the same current carrying capacity as the main busbar.
  4. Unless otherwise specified main and auxiliary busbar shall be air insulated type.
  5. A copper earth busbar sized at least 50% of the phase busbar shall be provided along the full length of the board.
  6. Phase identification of the busbar shall be done by painting the busbar by non-inflammable painting material or covered by a coloured heat resisting non-shrinkable PVC sleeving. Also all connections shall be

identified.

The colour to be adopted for identification shall be as follows:

Neutral	:	Black
Phase	:	Red, Yellow, Blue
Earth	:	Green

- C. Distribution board shall comply to 2.01 of section 16163.
- D. Circuit Breaker: The main and submain distribution board shall be equipped with moulded case circuit breaker complying to the requirements of Section 16450.
- E. The main distribution board shall have the instruments shown on the drawings.

### PART 3 - EXECUTION

#### 3.01 INSPECTION

- A. The Contractor must examine substrates and conditions under which work will be done and correct any unsatisfactory conditions. Do not proceed with work until all unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

#### 3.02 INSTALLATION

- A. In addition to the instructions contained herein, manufacturer's drawings and instruction books for the equipment and material to be installed hereunder must be followed explicitly except where manufacturer's instructions differ from these technical specifications.
- B. Check foundations, wall thicknesses and structural elements upon which equipment and materials shall be mounted to verify that there are no errors or omissions in locations or in position of anchor bolts. Any errors or omissions which may be disclosed by this inspection must be reported to the Engineer without delay.
- C. All devices and equipment mounted within the distribution boards and which require earthing shall have their conductive non-current carrying parts effectively bonded to cabinet. Earth bar to be mounted near base of cabinet for connection of equipment earthing conductors.
- D. Do not remove, alter, drill, load or connect to structures, except where required for by drawings or approved by the Engineer.
- E. Protect and maintain equipment and materials from time of delivery until

- accepted for operation by Engineer. This period includes, but is not limited to, storage prior to installation, erection phase, lay-up prior to operations, and preliminary operation.
- F. Store material and equipment off ground or floor.
  - G. Provide services for certain equipment such as space heaters, electrical testing, and maintenance of protective covers and coatings as required by manufacturer.
  - H. Prior to acceptance of installation correct all damage and corrosion occurring after delivery.
  - I. Use proper and adequate handling equipment and rigging at all times. Examine equipment and rigging and check at frequent intervals.
  - J. Install distribution boards and enclosures where indicated, in accordance with manufacturer's written instructions, applicable requirements of listed standards, and in compliance with recognized industry practices to ensure that products fulfil requirements.
  - K. Coordinate installation of distribution boards and enclosures with cable and raceway installation work.
  - L. Anchor enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically secure.
  - M. Provide electrical connections within enclosures.
  - N. Fill out distribution boards circuit directory card upon completion of installation work.
  - O. Distribution boards shall be mounted with their center lines approximately 1700 mm above the finished floor, except that the highest breaker shall in no case be more than 2000 mm above the finished floor.
  - P. Board directory, as a minimum, shall indicate breaker position number, equipment served, room name and number.
  - Q. All conductors shall have label tags affixed prior to trim installation.
  - R. All breaker positions shall be numbered.
  - S. All breaker trip ratings shall be readable without removing panel front cover.

**\*\* END OF SECTION \*\***

## **SECTION 16660**

### **EARTHING AND EARTH FAULT PROTECTION**

#### **PART 1 - GENERAL**

##### **1.01                      DESCRIPTION**

- A.     The work to be performed includes, but is not necessarily limited to, all work involved with the construction and assembly of a complete electrical earthing and bonding system as specified herein.

##### **1.02                      QUALITY ASSURANCE**

- A.     The Contractor is responsible for the quality of all its purchased items and as such, must develop and submit a supplier quality inspection plan to review. The inspection plan is to cover those items intended for shop inspection and the procedures for carrying out same.

B.     Manufacturer: Components of earthing and earth fault protection shall be the standard products of a manufacturer regularly engaged in manufacture of components of types and sizes required and complying with the requirements of the listed standards and whose products have been in satisfactory use in similar service for not less than 5 years.

- C.     Codes and Standards: Comply with requirements of the following codes and standards except as herein modified:

- |     |   |  |
|-----|---|--|
| 1.. | BSI   | British Standard Institution               |
|     | BS 7430   | Code of Practice for Earthing.             |
|     | BS 7671   | Requirements for Electrical Installations. |
| 2.  | IEC   | International Electrotechnical Commission. |
|     | IEC 60364-5-54 Earthing arrangements and protective conductors. |  |

##### **1.03                      TESTS AND ACCEPTANCE CRITERIA**

- A.     Earthing system shall be tested to assure mechanical and electrical continuity and compliance with the requirement of the standards. The overall resistance between any point on the earth installation and the general mass of the earth shall be less than 2.0 ohms. The earth resistance shall be measured in normally dry conditions and not less than 48 hours after rainfall.

- B.     The Contractor shall test every complete earth loop circuit comprising cables or cable sheaths and core conductors and these shall comply with the

maximum values specified in the listed standards.

- C. Material Test: Unless requirement is waived, materials shall be tested and manufacturer's test reports certifying that materials meet the requirement of the listed standards shall be submitted.

1.04

SUBMITTALS

- A. The Contractor shall submit to the Engineer the required documents to establish compliance with this section. Submittal shall include at least the following:

1. The Contractor shall prepare and submit for approval his proposals for the overall earthing and bonding system which shall include both Medium Voltage and Low Voltage Systems together with all auxiliary equipotential bonding. The proposal shall indicate the earth list locations, routes of earth bonding conductors and points of interface with equipment and accessories.

2. Manufacturer's Data including specifications, and dimensions for fittings and materials.

3. Shop Drawings including:

a. Diagrams detailing the complete earthing system including connections to all items of electrical plants and extraneous metal work.

b. Earthing conductor route and layout giving :

- i.. Location of all test links
- ii. Location of earthing pits

c. Details of earthing pits.

4. Test certificates: Submit certificates for tests carried out at site including:

a. Earth electrode resistance

b. Continuity of protection and equipotential bounding conductors.

c. Earth loop impedance.

PART 2 - PRODUCTS

2.01

GENERAL

- A. Every means of earthing and every protective conductor shall be selected and erected to satisfy the requirements of the listed standard.
- B. The cross-sectional area of every protective conductor shall be as per listed Standards.
- C. All switchboards, motor control centers, motor starter panels, and distribution boards shall have a copper earth bar to which shall be connected the earth conductor of the equipment.
- D. Main equipotential bonding conductors shall connect to the main earthing terminal for that installation extraneous conductive parts including: main water pipes, main gas pipes, other devices pipes and ducting, risers of air conditioning systems, and metallic parts of the building structures.
- E. Local supplementary bonding connections shall be made to metal parts where those parts are extraneous conductive parts and are simultaneously accessible with exposed conductive parts or other extraneous parts and where local equipotential bonding is provided Metalwork which may be required to be bonded includes baths, metal pipes, switches and taps.
- F. A circuit protective conductor of minimum cross-sectional area 2.5 sq.mm. stranded copper PVC insulated shall be drawn in with every circuit installed in conduit or trunking. The protective conductor and any trunking or tray system, together with the metallic sheathing of all cables, shall be electrically and mechanically solidly bonded with the earthed metal of switchgear, conduit boxes, distribution boards, motors and all other electrical apparatus, fixed/or connected by the Contractor.
- G. All apparatus or part thereof not solidly connected to the conduit and cable system shall be connected in an approved manner by solid copper conductor secured by substantial bonding clamps.

2.02

EARTH ELECTRODES

- A. The earth electrode shall be copperweld rod of 19 mm diameter and extensive type. It shall have a spike at one end and driving head at the other. The sectional rods shall be coupled with strong bronze couplers. The coupler shall be threaded to fit the rod section. For driving the rod into the ground threaded steel stud shall be used. A brass clamp of suitable size shall be provided for clamping the earth conductor to the earth rod. The top of earth electrode shall be enclosed in a concrete or brick lined pit with removable concrete or metal cover. Earth electrode shall be connected to its associated earth conductor through a link, which will be mounted above ground in an accessible position and as close as possible to the earth electrode. Each link shall comprise a bolted copper link studs, nuts and washers to take earth conductor and bolted lug for the cable connection to the electrode. The length of the electrode shall not be less than 3 m.

- B. Where multi-rods are used they shall be separated by a distance of not less than the driven length.
- C. The earthing system shall be earthed by sets of earth electrodes. The earth resistance of each electrode shall be measured separately and if not 2 ohms or less, a longer electrode, or sectional electrodes shall be used to obtain approximately double length.  
If a 2-ohm resistance is still unobtainable, another similar set of electrodes shall be installed, except that not over six separate electrodes need be installed at one location. Each earth electrode shall be enclosed in a concrete pit covered with an appropriate inspection cover.
- D. Bare copper tape buried at a minimum depth of 600mm shall be used for interconnection of rods.
- E. Where soil conditions make the use of rod type electrode impracticable a grid configuration may be used comprising horizontally buried bare copper tape of dimensions 25mm x 4mm minimum. Tape shall be buried at a minimum depth of 600mm.

## 2.03 EARTHING SYSTEM ARRANGMENT

- A. A loop type, low impedance, earthing system shall be installed in mechanical rooms, switchboards rooms, interconnecting all non-domestic equipment such that at least two earthing connections are provided for each major equipment. The loop shall consist of 4 x 25mm copper tape fixed by brass spacing saddles and brass countersunk screws at 600mm centers, all through joints being trimmed and riveted. Two opposite points of the loop shall be connected to two separate earth electrodes.
- B. Switchboards, motor control centers and similar large items of enclosed electrical equipment shall be connected so that the earth bus contained in each item is connected at each end to a different point in the earthing system. The earth bus then becomes a part of the earthing system.
- C. An earthing conductor shall be connected between the distribution board and the earthing system. The earthing conductor shall be connected to the earthing bus. The bus shall contain screw terminals to which the earthing conductor of each branch circuit shall be connected.
- D. Each branch circuit from a distribution board or other distribution equipment shall contain an insulated earthing conductor which shall be connected to the earthing bus in the distribution equipment, and to the receptacle, fixture, motor or other device, served by the branch circuit. The size of the earthing conductor shall be as required by the applicable standard.

E. Where items require the use of 4 core XLPE/SWA/PVC, or PVC/SWA/PVC cables a separate single core copper earth cable with green/yellow PVC insulation shall be run alongside the main power cable having a cross section of at least half that of the largest core of the associated power cable, except that the minimum size of the earth conductor shall not be less than 4 mm<sup>2</sup> in any circumstance and 16 mm<sup>2</sup> if cable is direct buried unless otherwise indicated. Under no circumstances shall the cable armouring be used as the sole method for earth continuity or for bonding purposes.

F. Where cables supply 3 phase A.C. motors they shall be 4 core with the fourth used as the earthing lead and suitably colour coded at each end.

G. On motor control centres or switchboards a copper earthing bar having a cross section of 50 x 10 mm will be fitted along the entire length of the board, and this earth bar will be solidly bonded to sub-station earth bar. All outgoing cables from a control centre shall be installed such that the earth continuity conductor or associated earth cable is effectively bonded to this main earth bar.

H. Where thermoplastic or PVC conduits or PVC trunking is installed a separate earth protective conductor shall be run inside the enclosure to ensure complete earth continuity throughout the system.

I. Where the protective earth conductor is formed by galvanized steel conduit, trunking or metal ducting, then the earthing arrangements shall be carried out in accordance with listed Standards.

J. An instrumentation earth shall be provided adjacent to the main earth bar and connected to it by a removable link.

## 2.04

### ELECTRICAL EARTHING CONDUCTORS:

A. All earthing conductors shall be copper conductor materials only. Materials shall be in conformity with the codes and standards and those specified elsewhere herein for electrical systems. Earthing conductors shall be as follows:

1. Copper tape of minimum size 25 x 4 mm.
2. Soft drawn copper stranded conductors, PVC covered.
3. Insulated copper conductors run in conduits.

## 2.05

### EARTHING CONNECTORS AND DEVICES

A. Connectors and devices used in the earthing systems shall be of copper or bronze materials, and applicable for the use whether specified by

manufacturers or otherwise required. All connectors and devices shall be compatible with the surfaces being bonded or shall be suitably surfaced or coated and comply with listed standards.

- B. Where steel conduits are not effectively earthed by firm contact with an earthed enclosure, earthing bushings shall be used on at least one end of the conduit run. The bushings shall be designed to screw onto the end of the conduit and have a separate screw type connector for the earthing wire.

## 2.06 EARTH TERMINAL

- A. Where specified, a main earth terminal shall be installed in a convenient location. This shall comprise a high conductivity copper bar of sectional area at least that of the main earthing conductor. The terminal shall be supported on porcelain barrel type insulators and wall-mounted.
- B. The terminal shall be of sufficient length to accommodate bolted copper tape connections to:
  - 1. The earthing conductor(s) between the earth terminal and earth electrodes.
  - 2. Circuit protective conductors between the earthing terminal and exposed conductive parts.
  - 3. The main equipotential bonding conductors between exposed and extraneous conductive parts.
  - 4. The system neutral earthing conductor (where specified).

Facilities (1) and (4) shall be removable with a tool to permit measurement and testing.

Earth studs shall have a minimum size of M8.

## 2.07 CABLE TRUNKING EARTHING

- A. Metallic trunking shall be provided with an earth continuous conductor bounded to each section.
- B. In addition, all trunking shall be electrically continuous by means of a 25 mm x 3 mm copper copper trunks across each joint in the system. The connection shall be made by means of tinned bolts and nuts 6 mm minimum diameter with flat and spring washers. The galvanising of the trunking shall be removed within 6 mm of jointing strap and painted with red oxide after installation of strap to prevent rusting.

2.08        FLEXIBLE CONDUITS

- A. Flexible conduits shall not be used as the sole means of providing earth continuity, an earth continuous conductor of appropriate size shall be provided.

2.09        RIGID METALLIC CONDUITS

- A. Rigid metallic conduits shall be provided with a separate insulated earth wire and the conduit itself may not be considered as the earthing system. All joints shall be made metallically and electrically continuous.

2.10        RIGID NON-METALLIC CONDUITS

- A. A separate insulated earth wire shall be drawn into all rigid non-metallic conduits.

2.11        CABLE TRAY AND LADDER

- A. Provide continuity between metallic tray and ladder components if metallic.
- B. Provide specified cross section copper equipment earthing conductor through entire length; bound to each component if metallic.

PART 3 – EXECUTION

3.01        INSTALLATION

- A. Additional rod electrodes shall be installed as required to achieve specified resistance to earth.
- B. An earthing pit with cover shall be provided at each rod location. Earthing pit top shall be flush with finished grade.
- C. Provide earthing electrode conductor and connect to reinforcing steel in foundation footing where indicated. Bond steel together.
- D. Provide bonding to meet Regulatory Requirements.
- E. Bond together metal siding not attached to earthed structure; bond to earth.
- F. Bond together each metallic raceway, pipe, duct and other metal object entering space under access floors.
- G. Provide isolated earthing conductor for circuits supplying electronic cash registers, personal computers and other sensitive electronic equipment as directed the Engineer.

- H. Earth bars and earthing equipment shall be provided for each earthing system and all main earth electrodes, earthing leads, neutral earth connections, etc., shall be connected to these.
- I. Main earthing conductors shall comprise tinned copper tapes of hard drawn, high conductivity copper strip.
- J. Earthing conductors shall be adequately sized for the maximum fault current and in no case shall be smaller than:
  - 1. 50 mm x 6 mm for High Voltage equipment.
  - 2. 38 mm x 4 mm for Low Voltage equipment.
- K. The non-conducting metal work of all electrical equipment shall be effectively earthed.
- L. All connections to the earth tape and any joints in the run of the tape shall be, tinned, riveted, sweated and electrically continuous. The minimum overlap of any connection be equal to the width of the larger of the two tapes. When less than four rivets are used, they shall be located diagonally across the joint. Final earth connections to motors shall be made by a bolted copper disconnecting link to facilitate removal of the motors without the need for bending the tape. Links shall be located for ease of inspection and testing. Earth tapes shall be fixed by means of non-ferrous spacer saddles, drilling of the conductors will not be permitted. Earth conductors within buildings shall be run in ducts or on the underside of control room floors where possible.
- M. Conduit or trunking shall not be used for earth continuity, but all conduit or trunking shall be connected to earth. Flexible conduits shall have an additional external earth connection adequately bonded at both ends. Where conduit and/or trunking is used to connect equipment not separately bonded to the earthing system a separate internal earth conductor shall be run, which shall be securely bonded directly to the respective equipment by means of a separate recognised earth terminal.
- N. The lead sheath and/or armour wires on main cables shall be solidly bonded and earthed to provide additional earth paths. Particular care shall be taken on cable termination boxes to ensure that the cable sheath and armour is adequately bonded to the associated item or plant.
- O. Particular care shall be taken to ensure earth continuity across items of equipment situated within a cable run. Should the design of such equipment not give an adequate and lasting continuity through its structural body, then additional earthing and conductors shall be provided to independently bond the cable sheaths together.
- P. Joints and terminal boxes in underground cables (if approved by the Engineer's Representative) shall be bridged by tinned copper of adequate cross section, bonded to the cable sheath.

- Q. Where armoured cables are installed, then the armouring must be bonded to earth using suitable glands with earthing tails. The armouring must not be used as the sole earthing conductor. Additional earthing shall be provided by means of a separate, insulated P.V.C. copper cable whose insulation is green or green/ yellow. This cable shall follow the same route as the supply cable and be taped to it at regular intervals. Alternatively an integral earth conductor shall be provided where multi-core cables are provided.
- R. Where M.I.C.C. cables are installed, the outer copper sheath may be used as the earth conductor. M.I.C.C./P.V.C. cables shall not be buried directly in the ground but shall be installed in a non-metallic pipe.
- Q. Substation and generator station systems shall be separately earthed and shall not be interconnected. Groups of electrodes shall be adequately spaced apart from each other.
- R. Each group shall comprise one or more interconnected earth electrodes, driven to a depth of 2m below the summer water table and with heads located at a depth to suit the disconnecting chamber position.
- S. A concrete disconnecting chamber having a removable cover and containing a disconnecting link for test purposes shall be provided over each earth electrode. The top of the chamber shall be at finished ground level, and the head of each electrode shall be within the disconnection chamber.
- T. The disconnecting link shall be of tinned copper, be not less than the connecting strip cross sectional area and have a generous contact area.
- U. Disconnecting bolts, nuts, locknuts and washers shall be made from phosphor bronze.
- V. Contractor shall be responsible for any rock drilling necessary for the installation of the earth electrodes, for the supply and installation of the concrete disconnecting chamber, and the provision of any chemicals required to assist in obtaining a satisfactory earth.
- W. The earth electrode interconnection shall be an electrically unbroken ring using P.V.C. insulated stranded copper conductor earthing cable sweated to the test links. The cable be adequately sized and of sufficiently low resistance to carry the maximum fault current for the clearing time of the protective equipment without undue temperature rise.
- X. Each group of earth electrodes shall be connected to the station earthing system by two PVC insulated stranded copper conductor earthing cables. The cables shall be sweated to opposite ends of the earth ring and to two different points on the station earthing system.
- Y. Groups of earth electrodes shall generally be located as close to the building housing the switchgear as practical, and where two groups are required they shall be located at opposite ends of the building.

- Z. The complete earthing system shall be protected against damage by corrosion where necessary.
- AA. Interface with lightning protection system installed under Section 16670.

END OF SECTION