

TECHNICAL SPECIFICATIONS

**PART 3
ELECTRICAL ENGINEERING SERVICES**

TABLE OF CONTENTS

Chapter 1	Basic Electrical Requirements
Chapter 2	Distribution, Sub distribution and Final Branch Circuit Panel boards
Chapter 3	Conduits, Wire ways, Supporting Systems and Related Accessories
Chapter 4	Wiring Devices and Disconnects
Chapter 5	General Lighting Installation
Chapter 6	Earthing System
Chapter 7	Lightning Protective System
Chapter 8	Solar System

CHAPTER 1
BASIC ELECTRICAL REQUIREMENTS

1 - GENERAL

1.1. RELATED DOCUMENTS:

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other chapters of part 3.

1.2. SCOPE OF WORK

1.2.1 The scope of electrical work for the Project will include but is not necessarily limited to:

A. Power Supply and Distribution consisting of:

- Sub-distribution and final branch circuit panel boards,
- Cables, wires and related accessories,
- Conduits, wire ways, supporting systems and related accessories,
- Earthing system. `

B. Lighting and Power Installations including:

- Functional indoor and outdoor lighting installations,
- Wiring devices including all lighting switches, isolating switches, socket - outlets, plates,

1.2.2. Unless otherwise specified, includes the supply, installation, testing and commissioning of the complete electrical systems, equipment and materials shown on the Drawings and/or described in the Specification together with all associated ancillary work, support work and builder's work in connection.

1.2.3. Incoming power supply and connection will be provided by the Local Power Authority at 220/380 V to the location shown on the Drawings.

1.3. GENERAL REQUIREMENTS

1.3.1. INSTALLATIONS GENERALLY:

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

1.4. DESIGN CONDITIONS

1.4.1. Nominal characteristics of power supply and distribution are as follows:

- A. low voltage : 380 V, 3 phase, 4 wire, solidly earthed neutral
- B. frequency : 50 Hz.

1.4.2. DISTRIBUTION SYSTEMS are to be supplied or derived from the voltage system previously described, as shown on the Drawings, or as otherwise specified.

1.4.3. EQUIPMENT is to be designed for the system voltage and frequency previously described, unless otherwise specified. Special provisions are to be made for equipment sensitive to power supply frequency and voltage variations and for equipment operated at other voltages/frequencies or by direct current sources.

1.4.4. CLIMATIC CONDITIONS: equipment, including transformers, switchgear, cables, relays, lighting fixtures, motors etc., is to be designed and derated for continuous and trouble free service under the following climatic conditions:

- A. altitude : at sea level
- B. maximum ambient temperature: 40 deg. C (in the shade)
- C. minimum ambient temperature: 4 deg. C
- D. maximum relative humidity: 90 %
- E. atmospheric conditions: 1 bar

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

1.4.5 REGULATIONS: carry out electrical work in accordance with the current issue of the local codes of practice, local power authority regulations and IEC Regulations for Electrical Installations, where not in contradiction with the local codes of practice and regulations, herein referred to collectively as 'the Regulations'.

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

- | | |
|----------|--|
| IEC : | The International Electro-technical Commission |
| ISO : | The International Standardization Organization |
| EN : | European Norm |
| NF-USE : | The French Regulation |
| BS : | British Standards |

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

1.5. EQUIPMENT AND MATERIALS

1.5.1. AVAILABILITY: confirm availability of equipment and materials proposed for use in the work prior to submission for approval. If, after approval, equipment or materials cease to be available, submit alternative items of equal quality and type for approval.

- 1.5.2. **ACCEPTANCE BY AUTHORITY:** confirm that proposed equipment and material characteristics where required are compatible with the requirements of the Local Power Authority or other authorities having jurisdiction and are acceptable to them. Inform the Engineer of any modifications necessary to comply with the Local Power Authority's requirements.
- 1.5.3. **MANUFACTURERS' STANDARDS:** equipment is to be the latest standard product of the manufacturer. Component parts are to be the product of a single manufacturer, unless otherwise approved and provided that components made by other manufacturers are of a standard design and are interchangeable.
- 1.5.4. **APPROVED MANUFACTURERS:** listing of approved manufacturers in the Specification does not necessarily constitute approval of their standard products as equal to those specified. As certain that listed manufacturers are able to supply equipment and material in conformity with the Specification.
- 1.5.5. **LABEL AND IDENTIFY** all equipment, instruments, control and electrical devices etc. to indicate duty, service or function, to the satisfaction of the Engineer. Labels are to be laminated plastic or anodized aluminum discs with black surface and white core with incised lettering in English or Arabic to the satisfaction of the Engineer. Alternative methods of labelling may be submitted for approval. Fix labels with non-corrodible screws to equipment, or to adjacent permanent surfaces or as approved by the Engineer.
- 1.5.6. **EQUIPMENT NAMEPLATES** are to be non-corroding, robust metal, inscribed in English, and firmly fixed to equipment at factory. Nameplates are to indicate name and address of manufacturer, model, serial number,

ic characteristics and ratings of equipment and are to include elementary diagrams etc., all in accordance with the Standards.

1.6. SUBMISSIONS

- 1.6.1. **GENERALLY:** submit for approval, manufacturers' technical literature, shop and construction drawings and other information required by the Specification, before ordering equipment or materials and before executing any related work on site.
- 1.6.2. **TECHNICAL LITERATURE** is to include detailed manufacturers' specifications and original catalogues or catalogue cuts, characteristics, model number, application and operating criteria of all equipment and materials, together with other information necessary to satisfy the Engineer that proposed equipment and systems are suitable and adequate.
- 1.6.3. **SHOP AND CONSTRUCTION DRAWINGS** are to demonstrate to the Engineer that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings are to clearly state the name and location of the work, the names of the Engineer and Contractor, submission date, cross-references to the Drawings and Specification and the specific reference number, location, service and function of each item.
- 1.6.4. **LIST OF PROPOSED MANUFACTURERS** of all equipment and materials, including all items for which choice of manufacturer is at the discretion of the Contractor, is to be submitted for approval.

- 1.6.5. **TEST CERTIFICATES AND REPORTS:** where required by the Specification, submit manufacturer's type and routine test certificates and reports for equipment and devices. Complete test results are to be submitted in clearly identified and organized booklets, indicating item of equipment, make, model, type, date of tests, type of tests, descriptions and procedures.
- 1.6.6. **LABORATORY TESTS:** if manufacturer's test certificates are considered unsatisfactory, then independent laboratory tests are to be carried out on equipment in accordance with the Specification and the Standards, as required by the Engineer.
- 1.6.7. **SPARE PARTS SCHEDULES:** submit with the Tender itemised schedules of spare parts to be provided, as required by the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.
- 1.6.8. **TOOLS AND INSTRUMENTS SCHEDULES:** submit with the Tender itemized schedules of tools and instruments to be provided, as required by the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.
- 1.6.9. **LABELLING SCHEDULE:** submit for approval, prior to installation, a schedule of all equipment and devices to be labeled and the suggested details, lettering, position and fixing methods of each label indicating its application.
- 1.6.10 **SAMPLES:** submit samples of all equipment and materials for approval. Major items of equipment for which samples cannot be submitted are to be demonstrated in existing installations or by manufacturer's information, test certificates and reports.

2 - TESTS ON SITE, RECORDS, TRAINING AND MAINTENANCE

2.1. TESTS ON SITE

- 2.1.1. **GENERALLY:** carry out inspection and acceptance tests on site on each complete system, before final placement into service, in accordance with the Regulations and Standards, as described in the Specification and required by the Engineer.

2.2. RECORDS

- 2.2.1. **GENERALLY:** not later than the date of substantial completion, provide the Engineer with four copies of all approved as-installed drawings, test records, manufacturers' guarantees and warranties, operating and maintenance manuals and other records required by the Specification.
- 2.2.2. **OPERATING AND MAINTENANCE MANUALS** are to contain the following:
- A. Technical description of each system and item of equipment installed, written to ensure that the Employer's staff fully understand the scope and facilities provided.
 - B. Schedules (system by system) of equipment installed giving manufacturer, catalogue list numbers, model, rating, capacity and operating characteristics; each item is to have a unique code and number, cross- referenced to the diagrammatic drawings and layout drawings.
 - C. Manufacturers' lists of recommended spare parts for items subject to wear and deterioration, giving expected running period and indicating specifically those items which may involve extended deliveries.

2.3. MAINTENANCE

2.3.1. MAINTENANCE CONTRACTS: where required by the Specification, submit supplementary proposals for annual maintenance contracts. The proposals are to:

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

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

CHAPTER 2
DISTRIBUTION, SUBDISTRIBUTION
AND FINAL BRANCH CIRCUIT PANELBOARDS

1. GENERAL

A. ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of the chapter1 of the Specification.

B. DESCRIPTION OF WORK: panel boards for distribution and sub distribution of electric power and for protection of circuits, including fixing and supporting materials and materials for termination of feeders, sub-circuits and branch circuits.

C. STANDARDS: panel boards generally are to comply with the requirements of IEC EN 60439-1, Factory-Built Assemblies of Low Voltage Switchgear and Control Gear. Exceptionally, they may not be factory-built nor type tested.

D. DESIGNATIONS: panel boards are designated on the Drawings and in the Schedules as follow:

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

E. EQUIPMENT DATA: submit data for approval including, but not limited to, the following:

1. Manufacturers' catalogues indicating specific equipment selected.
2. Types of panel boards and circuit breaker characteristics including duties and ratings compensation at and above 40 deg. C ambient conditions and corresponding temperatures within the enclosures.
3. Dimensions of panels and specific contents of each panelboard.
4. Integrated equipment tabulations for coordinated short- circuit series combinations of circuit breakers (cascading and discrimination).

F. TESTS AND CERTIFICATES: submit complete certified manufacturer's type test and routine test records in accordance with the Standards.

G. APPROVED MANUFACTURERS: obtain panelboards from one of the following:

1. Merlin Gerin, Telemecanique (Schneider) (France)
2. Klockner Moeller (Germany)
3. ABB (Germany)
4. Siemens – ITE (Germany)
5. Legrand (France)

2. PRODUCTS AND SYSTEMS

2.1 DISTRIBUTION, SUBDISTRIBUTION PANELBOARDS

2.1.1. GENERAL REQUIREMENTS

- A. RATED INSULATION VOLTAGE is to be in accordance with the respective Standards.
- B. PANELBOARDS are to be totally enclosed, dead front type, protection code IP 42 for indoor installations and IP 55 for outdoor installations, in accordance with IEC 529, and are to be factory designed and assembled.
- C. EARTHING BAR is to be provided in every panel board.
- D. PROTECTION is to be fully rated throughout the systems.
- E. CIRCUIT BREAKERS are to be non-fused type.

2.1.2. PANELBOARD ENCLOSURES

- A. TYPE: general purpose type, suitable for relevant ambient conditions, flush or surface mounted as shown on the Drawings, comprising box, trim, or trim and door to approved manufacturer's standards and sizes.

2.1.3 BUSBARS

- A. TYPE: one piece, 98% pure electrolytic copper, based on maximum total temperature rise of 20 deg. C over an ambient of 40 deg. C at full continuous rating. Bolted contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminum is not to be used for busbars or panel board parts.
- B. DESIGN: busbars are to be shrouded/insulated and rigidly designed so that branch circuit devices can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping. Busbars are to be full size without reduction. Busbar System and blank plates are to allow installation of future circuit devices, where indicated on the Drawings.
- C. NEUTRAL BAR is to be solid and fully insulated from cabinet or box. One solder-less box type set-screw connector is to be provided for neutral wire of each branch circuit and one bolted clamp-type connector or anti-turn lug with set-screw for main incoming neutral wire. Neutral is to be fully sized and rated as for phase busbars.
- D. EARTHING BAR is to be copper, brazed to panelboard cabinet, with bolted pressure connector for main conductor and one set-screw-type tunnel terminal
- E. for each outgoing conductor, to provide secure and reliable contact with all metal parts and enclosure.

2.1.4 MOULDED CASE CIRCUIT BREAKERS (MCCBs)

- A. TYPE: tested to approved standards, totally enclosed, moulded case, constructed from high quality, high temperature resistant, tropicalized, moulded insulating materials, for normal operation at maximum temperature within enclosures at point of application, and provided with front operated single toggle type handle mechanism for manual operation of main contacts in addition to automatic operation under overcurrent and short circuits conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all

poles. Ampere rating is to be clearly visible. All terminals are to be box lug or clamp type with set screws, suitable for copper or aluminum.

- B. MCCBs FOR SDB: To comply with IEC947-2 test sequences I, II, III, utilization category A, and are to have rated service short circuit breaking capacities to meet the electrical requirements at the panelboard location.
- C. FRAME SIZE is defined as maximum continuous current rating of circuit breaker which corresponds with its maximum trip range and which is to be related to minimum acceptable short-circuit interrupting ratings, based on fully rated interrupting duties: normal duty (N), high break (H), or current limiting (L), as specified.
- D. RESIDUAL CURRENT OPERATED EARTH LEAKAGE TRIP DEVICES (RCDs) are provided as add-on or built-in earth leakage accessories, where required and as shown on the Drawings. Protection against earth fault current, in addition to overcurrent and short-circuit protection, is to be in accordance with the Regulations. Trip current sensitivity on breakers for branch circuits is to be 30 mA, and for main breakers ratings are to be as shown on the Drawings. Circuit breakers are to include current transformer with tripping coil assembly, test button and trip free mechanism to ensure circuit breaker cannot be held closed against earth faults.

2.1.5 MINIATURE CIRCUIT BREAKERS (MCBs)

- A. TYPE: thermal magnetic non-adjustable type, tested in accordance with IEC 947.2 & IEC 898. Breaker type and short circuit interrupting ratings are mentioned on design drawings.
- B. MINIMUM SHORT-CIRCUIT BREAKING CAPACITIES are to be as shown on drawings. Contractor to check and confirm those levels (according to final equipment location: Transformers, MDBs, Panel Boards,....)
- C. CONSTRUCTION: MCBs are to be tropicalized for operation at ambient temperatures up to 70 deg. C within panelboard enclosure and humidity up to 95%, and are to be constructed from high quality, high temperature, moulded insulating materials. Guaranteed duties and characteristics are to be submitted for temperatures above 40 deg. C. MCBs and combinational devices are to be modular, of unified profile and mounted to a standard DIN rail.
- D. OPERATION: under overload conditions, thermal tripping is to provide close protection of insulated conductors. Under short-circuit conditions, magnetic trip is to operate at 5-10 times normal rated current (curve C characteristic). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milli-seconds.
- E. RATINGS: preferred rated currents are to be 6, 10, 16, 20, 25, 30, 40, 50, 60, 80 and 100 A, calibrated at 40 deg.C, available as 1+N, 2, 3 and 4-pole circuit breakers. Derating above 40 deg. C is not to exceed 1% per deg.C, and loading is not to exceed 70% of circuit breaker rating.
- F. RESIDUAL CURRENT DEVICES for earth leakage protective circuit breakers are to be add-on devices, or built-in and integral with the standard circuit breaker. Non-adjustable sensitivities of 30 mA, 100 mA and 300 mA are to be available for all ratings of 1+N, 2-pole and 4-pole circuit breakers.

2.2 PANELBOARDS

- A. **ARRANGEMENT:** to comprise set of homogeneous branch circuit breakers with unified profile and base, and one main circuit breaker or switch (as shown on drawings). Circuit breakers or other devices are to occupy modular spaces. Accommodation of contactors and split-bus arrangement or other devices is not to change regularity of standard box width.

2.2.1. FINAL BRANCH CIRCUIT PANELBOARDS SDB- TYPE MCB

INTERNAL ASSEMBLY: to comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with DIN rails in horizontal arrangement for single and three phase panels. Assembly is to be complete with earthing bar and one piece insulated bolt-on/comb-type phase busbar. Busbars are to be single-phase and neutral or 3-phase and neutral with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards. Panelboards are to comply with NFC and IEC standards. If the busbars rating exceeds 100 Amp (where the frame size of the main breaker is larger than 100 Amps), comb busbars shall not be used but still clause 2.1.3. of this specification shall apply.

- A. **SINGLE PHASE TYPE PANELBOARDS** are to be suitable for 240 V maximum service voltage, single-phase and neutral, with MCBs on branch circuits and main incoming.
- B. **SINGLE PHASE TYPE PANEL BOARD MAIN CIRCUIT BREAKER OR SWITCH DISCONNECTOR** is to be double-pole, with or without earth leakage device (RCD), as shown on the Schedules.
- C. **SINGLE-POLE + NEUTRAL (1 + N) AND DOUBLE-POLE (2P) MCBs** for 240 V service, are to have trip ratings between 6 A and 50 A, with ICU (n)/ICS as required in the Schedules.
- D. **THREE PHASE TYPE PANELBOARDS** are to be suitable for up to 415 V a.c. maximum service voltage, 3 phase and neutral, with MCBs on branch circuits and 4 pole switch disconnect or circuit breaker, main incoming, as shown in the Schedules or on the Drawings.
- E. **FOUR-POLE BRANCH CIRCUIT BREAKERS** are to have trip ratings between 6A and 100A, with ICU/ICS as required in the Schedules.
- G. **THREE PHASE TYPE PANELBOARD MAIN SWITCH DISCONNECTOR OR CIRCUIT BREAKER** is to be four-pole, with or without earth leakage device (RCD), as shown on the schedules.
- H. **SHORT-CIRCUIT RATING:** THREE PHASE panel boards may only have an integrated equipment (series) short-circuit rating in accordance with calculations.

3. FIELD AND INSTALLATION WORK

3.1 INSTALLATION

A. FIXING GENERALLY:

- Align, level and securely fasten panelboards to structure
- Fix surface mounted outdoor panelboards at least 25mm from wall ensuring supporting members do not prevent flow of air.
- Do not use connecting conduits to support panelboards
- Close unused openings in panelboard cabinets.

B. PANELBOARD INTERIORS: do not install in cabinets until all conduit connections to cabinet have been completed.

C. WIRING INSIDE PANELBOARDS: to be neatly arranged, accessible and strapped to prevent tension on circuit breaker terminals. Tap-off connections are to be split and bolted type, fully insulated. Wiring shall be arranged on terminals and connection blocks with marking as indicated in section 16120 of the specifications.

D. TRIM: fix plumb and square prior to painting. Fix trim for flush mounted cabinets flush with wall surface finish.

E. PROTECTION: treat concealed surfaces of recessed cabinets with heavy field application of water-proof compound prior to installation.

3.2. INSPECTION AND TESTS ON SITE

A. GENERALLY: carry out sample tests, as required by the Engineer, on panel boards after installation, to verify short-circuit capability of circuit breakers and busbars. Inspect conditions within panel boards and verify insulation conditions by use of a megger.

B. CIRCUIT BREAKERS: tests are to include operation of every circuit breaker manually. Check automatic operation of selected circuit breakers, as required by the Engineer, by applying necessary short-circuit, overload and earth leakage current for tripping circuit breaker as applicable and compare with manufacturer's data/characteristic curves. Measure and report ambient temperature inside enclosure.

C. INSULATION CHECK TESTS: carry out insulation tests on all busbars, between phases and between phases and earth/cabinet, and between neutral and earth. Record all readings, using 500 V megger for equipment on 240 V systems, and 1000 V megger for equipment on systems up to 600 V, for 1-minute, with circuit breakers in open position.

D. ROUTINE TESTS ON SITE are to be carried out, in accordance with the Standards, on all panel boards assembled from standardized components of the manufacturer outside the works of the manufacturer.

CHAPTER 3
CONDUITS, WIREWAYS, SUPPORTING SYSTEMS
AND RELATED ACCESSORIES

1. GENERAL

1.1. ELECTRICAL WORK GENERALLY:

is to be in accordance with the requirements of the chapter 1 of the Specification.

1.2. DESCRIPTION OF WORK:

raceways including conduits, wireways, cable trays and related installations and accessories necessary to support and protect cables, feeders, branch circuit wiring and wiring of low current systems, communications and signal cables.

1.3. REGULATIONS AND STANDARDS:

conduits, wireways, cables trays and fittings are to be designed, constructed and installed to give safe installation and reliable mechanical protection for wires and cables in accordance with the Regulations. Standards of products are to be as specified. Local production is prohibited if not tested and approved by a legal authority.

1.4. TECHNICAL DATA:

Submit data for approval including, but not limited to, the following:

- A. Manufacturer's catalogues with specifications of raceways including conduits, trunking etc. and related accessories.
- B. Samples of each type of raceway and accessory.

1.5. SHOP AND CONSTRUCTION DRAWINGS:

submit drawings for approval including, but not limited to, the followings:

- A. Exact routing of conduits, trunking etc. With indication of boxes, accessories and expansion joints, size of conduits and boxes
- B. Typical assembly details of installation of trunking, trays etc.
- C. Construction details of pull boxes.
- D. Typical installation details including connection of conduits to metal enclosure. Connections of flexible conduits, vapour- tight installations in cold rooms, liquid tight flexible metallic outdoors etc. and earthing connections.

1.6. APPROVED MANUFACTURERS:

obtain conduit, wireways and related accessories from one of the following or other equal and approved:

- A. UNIVOLT (Austria)
 - B. EGA Tubes (England)
 - C. DIELECTRIX (England)
 - D. Siemens (Germany)
 - E. Simplex (England)
- duct (UAE)

2. PRODUCTS AND SYSTEMS

2.1. CONDUITS AND ACCESSORIES

2.1.1. RIGID & FLEXIBLE METAL CONDUIT

- A. MATERIAL: steel, cold rolled and annealed, non-threaded type, formed from continuous length of helically wound and interlocked strip steel, with fused zinc coating on inside and outside.
Black enameled or hot dipped galvanized, L= 3m, screwed on both ends to NF-C-68-100. Locally manufactured conduits shall not be accepted.
- B. LIQUID- TIGHT FLEXIBLE METALLIC CONDUIT: is to have PVC jacket extruded over core.
- C. FITTINGS GENERALLY: thread less, hinged clamp type, hot dipped galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.
- D. STRAIGHT CONNECTORS: one piece body, female type, hot dipped galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.
- E. ANGLE CONNECTORS: of 45 or 90 degree and terminal connectors are to be as specified for straight connectors, except that body is to be two-piece with removable upper section.

2.1.2. RIGID MEDIUM GAUGE PVC CONDUIT.

- A. MATERIAL: rigid un-plasticized, could form a bend with PVC accessories, polyvinyl chloride with high impact and high temperature resistance, flame retardant, non hygroscopic and non-porous, compressive strength \geq 750 N, to CEE 26, BS 4607 and BS 6099, DIN 49026, NFC 68-107 or other equal and approved standards conforming to IEC 423.
- B. FITTINGS GENERALLY: unbreakable, non-inflammable, self-extinguishing, moulded plastic.
- C. ASSEMBLY: conduits, boxes and accessories are to be assembled by cementing, using manufacturer's recommended products and appropriate connectors or spouts are available use smooth bore male PVC bushes and sockets.

2.1.3. FLEXIBLE MEDIUM GAUGE PVC CONDUIT

- A. MATERIAL: flame retardant, heat resistant, non-hygroscopic PVC, high resistance to impact, ribbed on circumference for flexibility.

3. FIELD AND INSTALLATION WORK

3.1. CONDUIT AND WIREWAYS GENERALLY

- A. USE: unless otherwise specifically indicated all light and power circuits, communications, signal and low current systems wiring are to be drawn inside conduits or wireways up to the various electric power consuming equipment as shown on the Drawings. Separate conduit and wireways installations are to be used for LV cables/wires normal light and power circuits, emergency light and power circuits and communication, signal and other low current systems wiring.
- B. BOXES: junction, pull and splice boxes of ample capacity are to be provided as indicated or required. Boxes are to remain permanently accessible.

- C. **TOOLS AND ACCESSORIES:** for forming and installing conduit and wireway systems are to be purpose made for the particular application and used in accordance with manufacturer's instructions.
- D. **FIXING:** conduits and wireway installations are to be concealed as much as possible.
- E. **SIZES:** Unless otherwise specified conduits and wireways sizes, not shown on the Drawings, are to be selected in accordance with the tables on design drawings and in relation to the number and size of conductors. Minimum size of conduit for all applications is to be 20 mm diameter, unless otherwise shown on the Drawings.
- F. **MECHANICAL CONTINUITY:** conduits and wireways are to be effectively joined together and connected to electrical boxes, fittings and cabinets to provide firm mechanical assembly. Earthing jumpers are to be installed on steel conduits where required to ensure effective electrical continuity irrespective of whether a protective earth conductor is required or not.

3.2. PVC CONDUITS

- A. **COUPLING OF CONDUIT** and/ or termination into spouted fittings are to be made watertight and permanent using special cement.
- B. **TERMINATION:** connect conduits terminating in switchgear, fuseboards, trunking, adaptable boxes or non-spouted enclosures etc, with smooth bore male PVC bushes and sockets.
- C. **ENDS OF CONDUIT** end conduit fittings are to be cleaned and jointed using
- D. PVC cement recommended by manufacturer.
- E. **SEMI-PERMANENT ADHESIVE:** use in joints requiring expansion couplers.

3.3. EMBEDDED CONDUITS

- A. **CONDUITS IN CONCRETE SLABS:** place conduits parallel to main reinforcing steel.
- B. **CONDUITS IN PARTITIONS OR SIDE WALLS:** horizontal or cross runs are to be avoided.
- C. **PULL-BOXES** are not to be used. If unavoidable, pull-boxes may be approved if located inconspicuously.
- D. **CONDUITS IN FLOOR OF BEDS ON GRADE:** encase in concrete, minimum thickness 50 mm or to thickness allowed by architectural detail.
- E. **PVC CONDUITS IN REINFORCED CONCRETE STRUCTURES** are generally to be installed after placing reinforcement and before concreting, if protected against damage, or are to be placed in grooves in formed in the concrete, if approved.

3.4. EXPOSED CONDUITS

- A. CONDUITS ON WALLS: run neatly, horizontally or vertically.
- B. SUPPORTS: use approved clamps, hangers or clips fastened by machine screws to expansion sleeves in inserts or to lead anchors.
- C. SPACING OF CLAMPS OR CLIPS for supporting steel conduits is not to be greater than:

<u>Conduit Size</u> <u>mm (inches)</u>	<u>Maximum Spacing of Supports</u> <u>meters</u>
20 (3/4)	1.5 m
25 (1)	1.5 m
32-38 (1-1/4-1-1/2)	2 m

- D. SPACING OF CLAMPS OR CLIPS for supporting PVC conduits is not to be greater than.

<u>Conduit Size</u> <u>mm (inches)</u>	<u>Maximum Spacing of Supports</u> <u>meters</u>
20 (3/4)	0.60
25-50 (1-2)	0.75
63-75 (2-1/2-3)	0.90

- E. BENDS AND FITTINGS: firmly fasten conduit at each side of bends and within 900 mm of each outlet box, junction box, cabinet or fitting.
- F. OUTLETS: do not run more than one conduit to any surface wall outlet. Install junction box on home run near to ceiling level and tap-off vertical conduit to outlet box below.

CHAPTER 4
WIRING DEVICES AND DISCONNECTS

1. GENERAL

1.1. GENERAL WORK GENERALLY

is to be in accordance with the requirements of the chapter 1 of the Specification.

1.2. DESCRIPTION OF WORK:

wiring devices, lighting switches, socket outlets, cord outlets, automatic and manual lighting control equipment, dimmers, outlet boxes and plates, disconnect switches etc.

1.3. STANDARDS:

components are to be standard manufactured items, uniform and modular, complying with one set of approved Standards.

1.4. EQUIPMENT DATA:

submit data for approval, including catalogues, detailed literature, manufacturer's name, catalogue number, rating, specification, overall dimensions and special features, as applicable for each item.

1.5. SHOP AND CONSTRUCTION DRAWINGS:

submit drawings for approval including, but not limited to, the following:

- A. Exact indication of position of each item and outlet box and fitting on layout drawings, with box and equipment types and sizes.

1.6. SAMPLES:

submit samples of each type of device for approval, unless otherwise agreed in writing by the Engineer.

2. PRODUCT AND SYSTEMS

2.1. FITTINGS

2.1.1. OUTLET BOXES AND PLATES GENERALLY

- A. SURFACE OR RECESSED BOXES are to be suitable for type of related conduit or cable system. Shapes and sizes of boxes are to be compatible standards as switches, socket outlets and lighting fixtures selected and of various types and mounting methods required.
- B. UNUSED OPENINGS in outlet boxes are to be closed with knock-out closers manufactured for the purpose.
- C. BLANK PLATES: blank plates are to be installed on outlet boxes on which no apparatus is installed or where apparatus installed does not have suitable cover for box. Blanks plates for wall outlets are to be attached by a bridge with slots for horizontal and vertical adjustment.

2.1.2. MOULDED PLASTIC OUTLET BOXES

- A. TYPE: boxes and covers used with PVC conduit systems are to be heavy gauge pressure moulded plastic, minimum 2 mm thick, self extinguishing, with softening point not less than 85 deg. C. Boxes are to have provision for securely terminating conduits and are to be manufacturer's standard for required application.
- B. FITTINGS: boxes are to have brass inset threads to receive cover screws and for mounting devices or accessories, push-fit brass earth terminals, and steel insert clips to provide additional support for pendants or for heat conduction. Neoprene gaskets are to be provided for weatherproof installations.

C. MANUFACTURERS: obtain moulded plastic outlet boxes from:

1. Egatube (England)
 2. M.K. (England)
 3. Legrand (France)
 4. B Tichino (Italy)
- Or other equal and approved.

2.1.3. SWITCHES

- A. GENERALLY: quick- make, quick- break type with silver alloy contacts in arc resisting moulded base, with toggle, rocker or push- button as specified, for inductive or resistive loads up to full rated capacity, and arranged for side and/or back connection.
- B. TYPES: single, two- way or intermediate, single pole or double pole, as shown on the Drawings.
- C. GENERAL LIGHTING SWITCH: 10 A 220 V a.c., rocker operated, grid- switch with plastic plate, for indoor installations in general, unless otherwise indicated.
1. Man: Legrand or other equal and approved.
- Ref: unless otherwise mentioned on drawings:
One way one gang 74010
One way greater or equal to two gang 74000
- D. PUSH BUTTON SWITCH, Ref unless otherwise mentioned on drawings:
One gang 74040
Two or larger than 74030.
- E. MANUAL SWITCH: 2 pole, for fractional single and three phase motors and appliances, to interrupt motor and induction loads, rated 20 A at 415 V a.c., toggle operated, with positive indication of on/off position of contacts.
1. Man: Merlin Gerin or other equal and approved.
 2. Ref: [(15006 + 13392) when installed as one gang] for single phase, (15007 + 13392) for three phase (without Neutral) and (15008 + 13392) for three phase (with Neutral).

2.1.4. SOCKET OUTLETS

- A. GENERALLY: to have injection moulded plastic base with self- adjusting, non-expanding contacts to prevent permanent distortion, arranged for side and/or back connection and with screw terminals accepting at least three parallel branch- circuit wires.
- B. TYPES: general-purpose socket outlets are to conform with standard German practice concerning layout & rating).
- C. DUPLEX SOCKETS are to be mounted in parallel under one common plate with break- off feature for two-circuit connection
- D. WEATHERPROOF SOCKET OUTLETS are to be any of the types indicated, enclosed in surface mounted cast metal box and with cover comprising spring- retained gasketed hinged flap. Enclosure is to be pre- designed box and cover for type of socket outlet specified.
- E. GERMAN STANDARD SOCKET: single phase, three wire for plug with 3 mm round pins at 19 mm centers, with grounding in accordance with standard German practice and rated 10/16 A, 250 V a.c.
 - 1. Man: Legrand or other equal and approved.
 - 2. Ref: 74130 (and 74132 for UPS).

2.1.5. PLUGS

- A. TYPE: compatible with type of socket outlet specified, break resistant, of impact resistant moulded insulating material (separable construction), with solid brass pins and cord grip and of shape providing easy hand- grip for removal.
- B. QUANTITY: supply number equal to 20% of total number of each type of socket outlet supplied.

2.1.6. SWITCH DISCONNECTOR (DISCONNECTING SWITCH)

- A. RATING: 690 V, 2,3 or 4 pole, load break, short- circuit make, in accordance with IEC 947-3, utilization category 22 for heating and lighting loads, category 23 for motor circuits, and with ampere rating shown on the Drawings.
- B. DESIGN: non- fusible, air- break switch disconnect, single throw, safety type, housed in separate metallic enclosure with arc quenching devices on each pole.
- C. OPERATING MECHANISM: quick- make, quick- break, independent of operator, with external operating handle mechanically interlocked to prevent opening door unless switch is in open position. Switch disconnect is to have provision for by- passing interlock. Position of handle is to be positive and clearly indicated on cover.
- D. ENCLOSURE: General purpose sheet steel for indoor use IP 42 and weather- proof type cast- metal or sheet steel for outdoor installations IP 65 IK 08, unless otherwise required or shown on the Drawings. Locking of operating handle is to be possible in open and closed positions.
- E. MANUFACTURERS: obtain switch disconnect from one of the following of the following or other equal and approved:
 - 1. Merlin Gerin (France)
 - 2. Klockner Moeller (Germany)

3. ABB (Germany)
4. Siemens (Germany)
5. Socomec (France)
6. Legrand (France)

3. FIELD AND INSTALLATION WORK

3.1. INSTALLATION

- A. LOCATIONS: the Drawings generally show approximate locations of outlets and equipment. Exact locations are to be determined from interior finishing and detail drawings. Any condition that would place an outlet in an unsuitable location is to be referred to the Engineer. Locate switches at strike sides of doors, whether shown on the Drawings or not. In locating outlets allow for overhead pipes, ducts, variations in arrangement, thickness of finishing, window trim, paneling and other architectural features.
- B. MOUNTING HEIGHTS for outlet boxes and similar equipment are to be uniform within the same or similar areas. Mounting is to be as shown on the Drawings or as approved by the Engineer. Unless otherwise shown or instructed, mount lighting switches and socket outlets generally at 1200 mm and 300 mm from finished floor level respectively. Mount switches with long dimension vertical and operating handle, if of the toggle type, up when in the on position.
- C. SINGLE POLE SWITCHES are to switch the phase wire. Do not run neutral wire through switches having neutral shunt or bridge.
- D. ADDITIONAL OUTLETS to those shown on the Drawings are to be provided as required by equipment manufacturers for control or other wiring.
- E. EXPOSED OUTLET BOXES: securely fasten to wall with machine screws to permanent inserts or lead anchors.
- F. RECESSED OUTLET BOXES: make neat openings, to the satisfaction of the Engineer, allowing for thickness of finishing and use extension rings if required. Repair damaged finishing to original condition before installation of fittings or plates.
- G. APPEARANCE: install exposed boxes and plates plumb, square and parallel to finished wall surface. Exposed plates covering recessed boxes are to rest neatly on wall surface without gaps, and fully covering the box.
- H. GROUPED OUTLETS: arrange neatly so that use of fittings is convenient and clear.
- I. WATERPROOF AND EXPLOSION- PROOF FITTINGS: follow manufacturer's instructions for installation and connection to conduit system to fully achieve required degree of protection.
- J. DAMAGED FITTINGS: reject damaged fittings or plates with damaged finish. Protect fittings and plates against damage after installation and handed over.
- K. CONNECTION OF APPLIANCE:
 1. Where appliance is designed to adapt directly to outlet box, extend electrical wiring to incoming terminals inside appliance.
 2. Where appliance is not designed to adapt to outlet box, install connecting wiring in flexible conduit firmly fixed to outlet box cover plate and to terminal box on appliance.

3.2. INSPECTION AND TEST ON SITE

- A. VISUAL INSPECTION: fittings and equipment are to be inspected for fixing and workmanship.
- B. MEGGER TESTS are to include switch and socket outlet tests together with insulation resistance of wiring installations.
- C. OPERATION: devices are to be tested for operation and are to perform as intended at full load without any signs of heating.

EQUIPMENT is to be insulation tested and observed, under full- load for not less than 3 days operation, with respect to undue heating and performance in general.

CHAPTER 5
GENERAL LIGHTING INSTALLATION

1. GENERAL

1.1. ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of the chapter 1 of the Specification.

1.2. DESCRIPTION OF WORK: complete indoor and outdoor lighting installations including fixtures, control gear, mounting provisions, accessories and connection to circuit wiring and to corresponding lighting control equipment.

1.3. FIXTURE DESIGN AND STANDARDS: the Specification and the Drawings are a guide to the selection of lighting characteristics and lighting fixtures, giving general features of construction, materials, method of installation and conditions of operation. Unless otherwise specified, fixtures are to be manufacturer's standard series, designed and manufactured for the purpose and application required, generally in accordance with the Schedule of Lighting Fixtures and complying with IEC 598 and CISPR 15.

1.4. DESIGN LAYOUT: fixture layout has been determined from photometric data of specified fixtures to achieve desired level and uniformity of illumination. Reflected ceiling plans are to be checked to ensure exact positions of fixtures with respect to structural members, ducts pipes, other installations and ceiling panels/tiles, where required.

1.5. EQUIPMENT DATA: submit data for approval including, but not limited to, the followings:

- A. Detailed literature on each fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principals.
- B. Details of changes to standard fixtures for adaptation to condition of installation and to the Specification.
- C. Photometric data for lighting calculations including polar light distribution curves, coefficient of utilization, glare classification, efficiency, depreciation factors etc.

1.6. SAMPLES: submit fully equipped sample of each fixture type, modified if required, together with color and texture samples of each fixture.

2. PRODUCTS AND SYSTEMS

2.1. COMPONENTS AND ACCESSORIES

2.1.1. LIGHTING FIXTURE CONSTRUCTION-GENERAL

A. GENERALLY: construction and wiring of fixtures are to comply with the Regulations and Standards. Fixtures are to be fabricated, assembled and wired entirely at factory. Manufacturer's name, factory inspection stamp and official quality label are to be fixed to each fixture supplied.

B. LIGHTING FIXTURES (LUMINAIRES): to be manufacturer's standard, as given in Lighting Fixture Schedules shown on the Drawings, or equal.

C. SHEET STEEL HOUSINGS: to be not less than 0.6 mm thick, and thicker when required by the Specification or the Standards.

D. SHEET STEEL REFLECTORS: to be not less than 0.5 mm thick.

E. ALUMINUM REFLECTORS: to be not less than 0.7 mm thick, unless otherwise approved.

F. FABRICATION: metalwork is to be mitred, welded and ground smooth without tool marks or burrs. Flat metal parts are to be stiffened by forming grooves and edges during fabrication. Metal parts are to have finish free from irregularities.

G. RUST-PROOF FERROUS BASE: ferrous metal parts are to be bonderized (treated with corrosion resistant phosphate solution) and given an approved rust-inhibiting prime coat before application of final finish.

H. FINISH FOR NON-REFLECTING METAL SURFACES: approved baked enamel paint. Paint color on fixture frames and trims is to be as specified or as selected by the Engineer.

I. FINISH FOR LIGHT REFLECTING SURFACES: white baked enamel paint having reflection factor not less than 85%. Mirror reflectors, where specified, are to be highly polished, anodized aluminum with reflection factors not less than 97%.

2.1.2. FLUORESCENT FIXTURES

A. LAMP HOLDERS GENERALLY: to IEC 400, heavy duty, moulded white plastic with non-corroding spring contacts.

B. LAMP HOLDERS FOR INDUSTRIAL FITTINGS: spring loaded turret type, heavy duty, dust protected.

C. BALLASTS GENERALLY: to IEC 82. Only single (36 W) or two-lamp (18 W) ballasts are to be used in any one fixture. Two-lamp ballasts are to be lead-lag, series type. Equipment is to be enclosed in sheet steel casing with corrosion resistant finish.

D. BALLAST THERMOSETTING COMPOUND is not to soften, liquify or support combustion under any operating condition or upon ballast failure, and is to fill ballast enclosure and dampen vibrations. Temperature rise, under normal operating conditions, is not to exceed 55 deg. C above maximum ambient temperature of 40 deg. C.

E. BALLAST PROTECTION: each ballast is to have one-time external fuse and fuse holder rated in accordance with manufacturer's instructions.

F. BALLAST TYPE: electronic or electronic high frequency dimmable type, as stated in fixture description and as shown on the drawings, power factor corrected to above 0.9, having manufacturer's lowest case temperature. Sound rating is not to exceed level given in the Standards. Harmonics to IEC EN 60929, radio interference suppression to IEC EN 55015 and immunity to IEC EN 61547. The ballast shall operate at a frequency not less than 30kHz.

G. BALLAST RATING: ballast is to be manufactured and certified for the specific lamp it controls and for operation from nominal power supply, with voltage and frequency equal to nominal voltage and frequency of distribution network.

H. CAPACITORS: to IEC 566, having snap-type connectors and fastening, bolt type M8, for fixing to fixture.

I. STARTERS, if required, are to comply with IEC 155, and are to be selected in conjunction with respective ballast and lamp.

3. FIELD AND INSTALLATION WORK

3.1. INSTALLATION

- A. GENERALLY: install fixture level, aligned and parallel or square to building lines and at uniform heights as shown on the Drawings or as approved by the Engineer. Make final height adjustment after installations.
- B. FIXTURE SUPPORT: provide fixture and/or fixture outlet boxes with hangers, brackets and flanged bolted fittings, as necessary, to support weight of fixture. Submit details of hangers etc. and method of fastening for approval. Rigidly secure fixture mounted on outlet boxes to fixture studs. Install hooks or extension pieces, when required, for proper installation. Provide one point of support in addition to the outlet box fixture stud for individually mounted fixtures longer than 600 mm.
- C. SUSPENDED CEILINGS: if ceiling construction is unable to support weight of fixtures without strain or deformation, suspend fixtures directly from building structure.
- D. SOLD CEILINGS: coordinate dimensions of recesses in ceilings with exact fixture dimensions and structural elements.
- E. CONTINUOUS ROWS: arrange fixture so that individual fixtures can be removed without dismantling remaining fixtures. Provide minimum spacing between fixtures.
- F. COVER PLATES: install cover plates over fixture outlet box or opening in ceiling or structure when left unused.
- G. FLUSH RECESSED FIXTURES: install to completely eliminate light leakage within fixture and between fixture and adjacent finished surface.
- H. VENTILATION: keep ventilation channels free after fixture is installed, if required by the design of the fixture.
- I. EARTH metal frames of fixtures as described in Section 219 of the Specification.
- J. TIGHTNESS: ensure that enclosed fixtures are reasonably insect/ dust tight when installed, and completely weather-proof for installations subject to weather conditions.
- K. LAMPS FOR PERMANENT INSTALLATION: place new lamps in fixtures immediately prior to hand-over and when instructed by the Engineer. Lamps used for temporary service are not to be used for final lamping of fixtures.

3.2. INSPECTION AND TESTS ON SITE

- A. VISUAL INSPECTION: check neatness of installation, uniformity of equipment and nameplates etc.
- B. ILLUMINATION MEASUREMENTS: to be taken at selected locations, to determine level and uniformity.
- C. OPERATION: check lighting installations for operation including control and regulation equipment.
- D. ELECTRICAL DATA: measure power factor, current and voltage at start for installations with discharge lamps.

CHAPTER 06
EARTHING SYSTEM

1. GENERAL

1.1. ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of the chapter 1 of the Specification.

1.2. DESCRIPTION OF WORK: complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TN-S system arrangement, including:

- A. Main earthing system.
- B. Main earthing terminals or bars.
- C. Electrical room earthing terminal.
- D. Exposed conductive parts of electrical equipment.
- E. Extraneous conductive parts.
- F. Standby generators earthing terminal.

1.3. REGULATIONS AND STANDARDS: carry out work in accordance with the following:

- A. IEC publications 364-3 and 364-41 Electrical installations in Buildings.
- B. Latest edition of NFC 15-100 Regulations.

1.4. DEFINITIONS OF TERMS used on the Drawings and in the Specification are as follows:

- A. EARTH: conductive mass of the Earth whose electric potential at any point is conventionally taken as zero.
- B. EARTH ELECTRODE: conductor or group of conductors in initial contact with, and providing electrical connection to, Earth.
- C. EXPOSED CONDUCTIVE PART: any part which can be readily touched and which is not a live part, but which may become live under fault conditions.
- D. MAIN EARTHING TERMINAL OR BAR: the terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing.

1.5. EQUIPMENT DATA: prior to ordering materials, submit data for approval including, but not limited to, manufacturer's catalogues for earth rods, connecting clamps, earthing conductors, protective conductors, bonding conductors, connectors and other accessories, exothermic welding kits and tools etc., and samples of samples conductors as requested.

1.6. SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

1. Exact location of earth pits, rods and details of installation and connection.
2. Exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering.
3. Cross sectional area of all earthing, protective and bonding conductors
4. Layout and details of earthing provisions at substations, generator rooms, switchgear, distribution panelboards etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.

1.7. APPROVED MANUFACTURERS: obtain materials from one of the following:

- A. BICC (England)
- B. Copperweld (U.S.A.)
- C. Furse (England)
- D. G.E.C. (England) or other equal and approved.

2. PRODUCTS AND SYSTEMS EARTHING SYSTEM (TYPE TN-S)

2.1. GENERAL REQUIREMENTS

A. COMPONENT PARTS of earthing system are to include the following:

1. Earth electrode (rods, tapes etc.)
2. main earthing terminals or bars
3. Earthing conductors
4. protective conductors
5. Equipotential bonding conductors
6. electrically independent earth electrodes for special systems with transient earth clamp (similar to ERICO TEC 100C) for connection to standard earthing electrodes (Following the recommendation of the NFC 15-100 with this respect.)
7. Accessories and termination fittings, bonding, welding kits and other materials.

B. EARTH ELECTRODE is to consist of one or more earth rods, interconnected by buried earthing tape or cable, which is to have a total combined resistance value, during any season of the year and before interconnection to other earthed systems or earthing means, not exceeding 3 ohm other wise use additional earth rods. Distance between two rods is not to be less than twice the length of one rod driven depth.

C. FUNCTIONAL EARTH ELECTRODE is to be provided separately from, but interconnected to general bus collecting all the earth at the building and to other earth electrode (s) through suitably rated (470 V) spark gap. Functional earth electrodes are to be used for earthing electronic equipment (communication equipment, digital processors, computers etc.) as required by the particular Section of the Specification and recommendation of manufacturer.

D. ALTERNATIVE EARTH ELECTRODE: other types of earth electrode may be used, after approval, including:

1. Cast iron pipes with special surround material
2. Copper plate (s)
3. Tape mats (strips)

4. MAIN EARTHING BAR is to be provided at point of service entrance or main distribution room, and as described in the Specification or shown on the Drawings, to which all earthing conductors, protective conductors and bonding conductors are to be connected. Two insulated main earthing conductors are to be provided, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. conductor is to be sized to carry maximum earth fault current of system at point of application with final conductor temperature not exceeding 160 deg. C for at least 5 seconds. Main earthing conductors are to be minimum 95 mm² bare copper conductor or as otherwise required by the particular Section of the B.O.Q.

5. TESTING JOINTS (TEST LINKS) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminal or bar earth electrode. A bus system shall allow the disconnection of the lightning earth cable from the other earth cable in order to provide a separate test for each earth.

6. PROTECTIVE CONDUCTORS are to be separate for each circuit. Where protective conductor is common to several circuits, cross-sectional area of protective conductor is to be the largest of the conductor sizes. Unless otherwise mentioned the selection of sizes is to be in accordance with Table 54F of IEE Regulations.

7. PROTECTIVE CONDUCTORS are not to be formed by conduit, trunking, ducting or the like. Where armored cable is specified and armour is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the Drawings.

8. CONTINUITY OF PROTECTIVE CONDUCTORS: series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and/ or brazing to continuous protective conductors which are to be insulated by moulded materials.

9. MAIN EQUIPOTENTIAL BONDING: main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry/exit of services and main earthing bar. Where meters are installed, bonding is to be made on the premises side of the meter. Cross-sections of conductors are not to be less than half of the earthing conductors connected thereto, and minimum 6 mm².

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

11. SAFETY ELECTRICAL CONNECTION- DO NOT REMOVE.

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

13. IDENTIFICATION: source earthing conductor is to be identified along its entire length by continuous green/yellow insulation labelled 'earthing'.

2.2. EARTHING OF MAIN DISTRIBUTION BOARDS, PANELBOARDS, LIGHTING INSTALLATIONS AND WIRING ACCESSORIES

- A. MAIN EARTHING BAR is to be provided in location mentioned on drawings and connected to earth network by insulated conductor (size as mentioned on drawings) via testing joints.
- B. DISTRIBUTION, LIGHTING AND POWER PANELBOARDS are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panelboards with respective main building earthing bar.
- C. SOCKET OUTLETS are to be earthed by protective conductor looped around with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet terminal is to be connected.
- D. LIGHTING FIXTURES AND OTHER EXPOSED CONDUCTIVE PARTS of electrical installations, such as switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panelboards.

2.3. MATERIALS AND PRODUCTS

- A. EARTH ROD: copper clad steel, 20 mm diameter, 1.2 m length, extendible as necessary (minimum 2) to obtain required earth resistance. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated thereto.
- B. BURIED EARTH CONDUCTORS: annealed copper conductors 95 mm² cross-section.
- C. TAPS MATS: where earth rods are not likely to be used, earth electrode is to consist of parallel and perpendicular copper strip, 2.4 m apart, welded together by exothermic welds to form a grid. Tape is to be 25x25 mm strip conductor.
- D. EARTH PIT: pre-cast, square or circular section concrete hand-hole (minimum 450 mm internal diameter), with concrete cover, and extending to about 150 mm below top of earth rod. Earth pit is to be provided for each earth rod where connected to an earthing conductor. Cover is to have inset brass plate with inscription 'Earth pit-Do Not Remove.
- E. EARTHING CONDUCTORS: insulated (green/yellow) or bare copper conductor as described in the Specification for the particular application.
- F. TESTING JOINTS (TEST LINKS): copper or copper alloy, with bolted end connections, disconnectable by use of a tool, and suitably sized for earthing conductors or earth bar connection. Links are to be fixed to porcelain or other approved insulating supports. Contact surfaces are to be tinned.
- G. PROTECTIVE CONDUCTORS: single core stranded annealed copper, PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming parts of a multi-core cable, color coded.
- H. MAIN EARTHING BAR: hard drawn copper, 40x4 mm where formed into a closed loop, and 50x6 mm where open ended. Earth bar is to be labelled Main Earth Bar and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.
- I. PROTECTIVE BONDING CONDUCTORS: bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross- sectional area as described in sub-section 1 hereof.
- J. EARTHING ACCESSORIES: copper or copper alloy, purpose made, of approved design, compatible with points of connection, and of adequate cross- section and current carrying capacity. Connectors and clamps are to be bolted type. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys.

3. FIELD AND INSTALLATION WORK

3.1 INSTALLATION

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

CHAPTER 07
LIGHTNING PROTECTIVE SYSTEM

1. GENERAL

1.1. ELECTRICAL WORK GENERALLY is to be in accordance with the requirements.

1.2. DESCRIPTION OF WORK: air termination network, down conductors, earth termination network, bonding to prevent side flashing and accessories.

1.3. STANDARDS: work is to comply with NFC17-102.

1.4. TECHNICAL DATA: submit data for approval including manufacturer's illustrated catalogues with description and specification of component parts for Protective terminations, conductors, fasteners, testing joints (test links), earth rods, connectors, wall inserts and bolts and any accessories forming part of the lightning protective system.

1.5. SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including but not limited to, the followings:

A. Exact location and routing of roof and down conductors with indication of sleeves and types of fixings.

B. Exact location of earth pits and routing of interconnecting ring

C. Typical details of jointing and bonding.

1.6. AS- BUILT DRAWINGS: provide as- built drawings and indicate nature of soil, special earthing arrangements, date and particulars of salting if used, test conditions and results obtained.

1.7. MANUFACTURERS: obtain equipment, manufactured specifically for lightning protection, from one of the following:

- A. Helita (France)
- B. Franklin (France).

2. PRODUCTS AND SYSTEMS

COMPONENTS AND ACCESSORIES

2.1. TECHNICAL REQUIREMENTS

A. LIGHTNING WITH PROTECTIVE ROD. Lightning protection based on the following principles:

The lightning Protective Rods works when the lightning approaches the ground, a brush discharge is initiated at the lightning conductor, the Protective Rod will urge the brush discharge to propagate in the direction of the descending leader after a long transition phase. The Protective Rod initiation advance permits to reduce the required time for the formation and continuous propagation of the ascending discharge and brings thus a higher efficiency for the lightning capture.

B. DOWN CONDUCTORS every down conductor has to have test link above ground for testing earth termination network, has to be protected against corrosion for 0.3 m above and below ground level, has to terminate in an earth electrode and has to be insulated with PVC or polyethylene (5 mm thick) from test link to electrode connection point.

C. EARTH TERMINATION NETWORK: earth electrodes are to be interconnected and buried with the top at least 1 m below ground surface and minimum 0.6 m from the foundations. All electrodes are to have resistance to earth (in ohms) not exceeding, tested with test link removed and before bonding to other services or other earth electrodes. Combined resistance to earth of whole network is not to exceed 5 ohms.

D. COMMON EARTHING: earth termination electrodes are to be interconnected in a ring around the structure and bonded to earth electrode of protective earthing system, forming a common earth ring of total resistance value to earth below the lower value of any of the two systems.

The protective rod shall have a 3 meters stainless steel mast to which additional mast units could be attached. The height of the tip of the protective rod shall be minimum 3 meters higher than any other object of the project.

The radius of protection R_p shall cover the whole project with the specified safety margin.

2.2. MATERIALS AND COMPONENTS

A. ROOF CONDUCTORS: bare, high conductivity, annealed copper strip, 25 x 3.0 mm.

B. OPERATION OF THE PROTECTIVE ROD

The Protective Rod tip plays a triple role:

- Collect the energy necessary to power the electrical device contained in the cylinder,
- Emit the brush discharges created by the high-voltage pulses,
- Capture the lightning current to convey it to the ground.

The metal disc is the upper part of the external air gap designed to convey the lightning current from the tip to the ground. The metal cylinder contains the electric device of the Protective Rod system that generates the brush discharges. The pole serves to fix the Protective Rod for installation. The connecting clamp must be fixed to it, together with the down conductor.

C. Rod solid copper with roll formed threads at base, bronze nut, cast gun metal terminal base of appropriate thickness and low resistance, and any other accessories for rigidly mounting to surface.

D. EARTH ROD: unless otherwise indicated on the drawings to be 20 mm diameter, 2.4 meter long, high strength, low carbon steel core of high tensile strength (600 N/mm²), grade 43 A of BS 4360, with 99.99% pure electrolytic copper molecularly bonded into steel core, 0.25 mm minimum thickness. Driving head is to be high strength steel. Couplings are to be long length silicon bronze, grade CS101 of BS 2874, internally threaded. Threads are to be rolled onto rod to ensure uniform layers of copper and strength.

E. INSPECTION (EARTH) PIT: precast concrete construction, of dimensions shown on the Drawings, with heavy duty cover and brass plate engraved 'Earth Pit Below' inset in cover. One pit is to be provided for each earth rod.

F. TEST LINKS: two- bolt split- coupling, copper alloy, made to join two ends of down conductor specified. Plate indicating position and number of electrodes is to be fitted above each test link.

G. BONDING CONDUCTORS: high conductivity, bare annealed copper tape, 20x3.0 mm minimum dimensions, or 70 mm² soft drawn stranded copper cable.

H. ACCESSORIES including supports, joints, fasteners, clamps, bonds, test links etc. are to be copper or copper alloy and specially manufactured for the purpose. Clamps and connectors are to be specifically designed and sized for clamping and connecting to the various shapes and surfaces of bonded metalwork. Bimetallic connectors are to be used between different materials. Galvanized or plated steel nails, screws and bolts will not be accepted on copper installations.

I. FLEXIBLE BONDING STRAPS: flexible annealed copper braid, 25x3.5 mm, suitable for bonding flat surfaces, cut to length required and with drilled flat terminals for bolted connections. Special bimetallic alloy terminals are to be provided for joining to aluminum conductive parts.

3. FIELD AND INSTALLATION WORK

3.1. INSTALLATION

A. SUPPORT ROOF AND DOWN CONDUCTORS using fasteners spaced at not more than 400 mm centers horizontally and vertically, and fixed by anchor bolts or lead inserts with machined screws.

B. BENDS IN CONDUCTORS are not to be less than 200 mm radius and are not to exceed 90 degree turn.

C. DOWN CONDUCTORS are to follow most direct path between air terminals and earth pit. Re-entrant loops are not permissible. Tight angle bends may be allowed where absolutely necessary at edge of roof, whereby length of loop in relation to distance between its start and end is kept

below eight times. Direct path is to be through an air space in a non- combustible, non- metallic duct with net cross- section 15 times area of conductor.

D. MECHANICAL PROTECTION OF DOWN CONDUCTORS: provide asbestos cement or PVC pipes underground, starting 0.3 m below ground and to a height of 1.2 m above ground. Test link is to be positioned 1.3 m above ground.

E. BOND EXPOSED METAL PARTS OF STRUCTURE to lightning protective system if clearance between any element of lightning system and metal part is less 1800 mm or the distance allowed by the Standard, whichever is smaller.

F. INSPECTION (EARTH) PIT is to extend 150 mm below top of earth rod. Cover earth rod connector with suitable protective compound which can be easily removed for inspection. Connector is not to be covered with backfill material and is to remain clean.

3.2. TESTS ON SITE AND RECORDS

A. RESISTANCE TO EARTH of each termination electrode and the network and of the complete bonded installation is to be measured during the dry season and checked against specified resistance.

B. ELECTRICAL CONTINUITY of conductors, bonds etc. is to be checked.

C. RECORDS: submit the following:

1. Actual layout and specification of components of the system
2. Nature of soil and characteristics and any special earthing arrangement
3. Test conditions and results.

CHAPTER 08
SOLAR SYSTEM

1. GENERAL

1.1. ELECTRICAL WORK GENERALLY is to be in accordance with the requirements.

1.2. DESCRIPTION OF WORK: PV Photovoltaic panels, grid inverter, solar batteries, hybrid inverter and accessories.

1.3. STANDARDS: work is to comply with international standards.

1.4. TECHNICAL DATA: submit data for approval including manufacturer's illustrated catalogues with description and specification of component parts.

1.5. SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including but not limited to, the followings:

A. Exact location and routing of Photovoltaic PV panels, cables and wires with indication of sleeves and types of fixings.

B. Exact location of solar batteries, inverters and all accessories.

C. Typical details of panel boards.

1.6. AS- BUILT DRAWINGS: provide as- built drawings for the system.

1.7. MANUFACTURERS: obtain equipment, manufactured specifically for electrical solar system from one of the European firms.

2. PRODUCTS AND SYSTEMS

COMPONENTS AND ACCESSORIES

2.1. TECHNICAL REQUIREMENTS

A. PV PHOTOVOLTAIC PANELS:

- The panels should be placed at the roof and its exact location shall be determined on site as per the environmental conditions (tilted angle).
- The panels are fabricated from multi crystalline (156 x 156mm), maximum weight of 18.6 kg, white back sheet with silver anodized aluminum alloy and a J box with IP 65 rated.

B. PV MOUNTINGS:

PV mountings should be:

- Corrosion resistant; made of 100% aluminum
- Quick, simple, virtually tool-free installation.
- System design based on the latest wind dynamics research.
- Reduced number of components for shorter mounting type.

C. SOLAR BATTERIES:

- Solar batteries should be located inside a room or cabinet and its exact number shall to be determined on site according to the solar system requirements.

D. INVERTERS:

- Three phase output voltage 380/220V or single phase output voltage 220V/50 Hz.
- Fixed load steady state: +/- 0.5% from no full load to full load.
- Dynamic output regulations: +10% - 8% with a load variation of 50%.
- Recovery time of the steady state value:

- < 20 ms for ΔU +/- 1%
- < 40 ms for ΔU +/- 0.5%
- Output frequency: 50 Hz
- Harmonic content: < 4%