J7 EMPORIUM, PAKISTAN

ELECTRICAL SPECIFICATION

PART 2 – LV INSTALLATIONS

DISTRIBUTION BOARDS, CABLE TRAYS AND BUSBARS

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DOCUMENT CONTROL RECORD

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Contents

Abbreviations

AC	Alternate Current
ACB	Air Circuit Breaker
BS	British Standard
BMS	Building Management System
CT	Current Transformer
DB	Distribution Board
DC	Direct Current
DN	Nominal Diameter
ELV	Extra Low Voltage
HDHC	Hard Drawn High Conductivity
HV	High Voltage
HRC	High Rupturing Capacity
ID	Interior Designer
IP	Ingress Protection
LV	Low Voltage
MCB	Miniature Circuit Breakers
MCCB	Moulded Case Circuit Breaker
NEC	National Electrical Code
SPD	Surge Protective Devices
UVT	Under Voltage Trip

1. LV Main Switchboards & Sub-Switchboards

1.1 General

All LV Main & Sub-switchboards, shall be designed and constructed in accordance with BS EN 61439-1 & BS EN 61439-2 and shall be self-contained, extensible, floor standing, metal clad, flush fronted, cubicle type with front and/or rear access built up from completely enclosed units housing circuit breakers, copper tinned HDHC busbars, moulded case circuit breakers, auto changeover switches, protective relays, control fuses, selector switches, indicating lights, meters, anti-condensation cubicle heaters, cable glands, etc. and all other items whether specified hereinafter or not suitable for indoor service in the environment conditions as specified elsewhere in this Specification at maximum continuous rating without exceeding the maximum temperature permitted by the relevant BS specification to which reference is made herein for operation on a 400/230 Volt 3 phase 50 Hz system operating with by solid earth neutral. All LV main & sub-switchboards shall be tested in accordance with arcing due to internal fault as per IEC 61641.

1.2 Rating

Generally, the LV Switchboard shall be in compliance with BS EN 61439, type-tested and capable as a whole of withstanding without damage the electrical, mechanical and thermal stresses produced under short circuit conditions equivalent to the prospective short circuit current as indicated on the Design Drawings at 400 V for 3 seconds in accordance with BS EN 61439-1 & BS EN 61439-2. However, sub- switchboards of the lower rupturing capacities compatible with the prospective short circuit current at the point of application may be considered if calculations and details could be submitted to substantiate the lower short circuit current at the sub- switchboards concerned.

The whole of the LV Switchboard shall be Form 4B, type tested and certified by A.S.T.A., K.E.M.A. or other recognized National or International Testing Authority. Test reports are to be submitted in Technical Submission.

1.3 Degree of Protection

The degree of protection for the switchgear enclosures shall be IP 21 in compliance with IEC 60529.

Ventilating openings and vent outlets shall be so arranged and shielded to achieve the same degree of protection as that specified. Such openings shall be of suitable mechanical strength.

Openings in cable entries, cover plates, etc. shall be designed such that when the cables are properly installed, the degree of protection shall be maintained.

Non-deteriorable rubber gaskets shall be provided between metal panels and on the covers, etc. to provide the specified degree as protection.

1.4 Design and Construction

Each cubicle framework shall be fabricated from rolled steel angle sections and shall be self-supporting when assembled and of standard size, uniform in height and depth. The cubicle roof, side panels and doors shall be of not less than 2 mm thick electro-zinc plated and passivated sheet steel with turned edges to the front panels and so framed as to provide a clean, flush and pleasing appearance and rigid construction without welded cross-struts. Where necessary, the cubicle shall be strengthened by horizontal and vertical folded channels and corner gussets.

Full access shall be provided to control equipment inside cubicles by means of suitable hinged doors secured with adequate numbers of locks. The opening or withdrawal of the doors shall necessitate the use of a key or tool. For all air circuit breakers and MCCB's, the doors shall be mechanically interlocked with the main switch to prevent any door being opened with the circuit breaker in the 'ON' position. The exterior of the cubicles shall be finished semi-gloss grey to colour no. 631 of B.S.381C with end plates and heads of any external fixing bolts or set screws similarly finished except those steel parts normally left bright which shall be cadmium plated and operating parts finished semi-gloss black.

The interior of each cubicle shall be finished matt white and shall be insect and vermin proof. The interior of each piece of equipment shall be clearly marked to show the phases with either coloured plastic discs screwed to fixed components or with coloured plastic sleeving for identification in accordance with BS EN 60445. Plastic tape will not be permitted.

Each main or sub switchboard shall be provided with 15% spare space.

1.5 Busbars and Secondary Wiring

Busbar markings and arrangements, connections and grade of copper shall all comply as appropriate with BS EN 61439-1.

The switchboards shall be so arranged that the main busbars run horizontally through each sectional length in a ventilated separate compartment. The busbars shall be of adequate cross-sectional area to meet the type test requirements, temperature rise limits as set out in Table 6 of IEC 61439-1 and to give the current ratings as shown on the Design Drawings after allowing for all necessary derating factors. The main busbars shall comprise four rectangular section bars of equal cross sectional areas (i.e. full size neutral) fabricated from hard drawn high conductivity copper, electro-tinned for the entire length, rigidly mounted on proprietary made non-hygroscopic insulators with connections from the busbars to the circuit breakers and switches effected by means of copper bars or rods securely clamped to the bars and identified by means of coloured plastic sleeving or proper painting to indicate the phase colours.

Secondary busbars shall be HDHC copper similar to the main bars. Copper connections shall be provided from busbars to the distribution equipment and when required, from distribution equipment to the cable terminations. Connections shall be so arranged that they do not impede access to cable entries and subsequent maintenance of the switchboards. All connections shall be manufactured from HDHC copper and the entire connecting surface shall be tinned; however, for lower rated circuits of 100 Amp or below, PVC/PVC single core cables may be permitted for connections provided the cables are of adequate cross sectional area to withstand the prospective short circuit current and thermal stresses. Insulated conductors shall not rest against bare live parts at different potentials or sharp edges and shall be adequately supported. PVC/PVC cable connections where permitted shall be identified with colour PVC sleeving.

All secondary wiring shall be of 600/1000-Volt grade PVC/PVC cables with multi-strand copper conductor of not less than 2.5 sq mm section and shall be fixed securely without strain by cleats of the compression type. Multiple runs of wiring shall be bundled with cable trunkings specially designed for installation within the switchboards. For the purpose of identification, different insulation colours shall be provided to distinguish the circuits of different Voltages and functions and the circuits shall terminate at separate terminal blocks placed in an easily accessible position for testing at site, with coded ferrules on both ends of each conductor.

No connectors or soldered joints shall be permitted in the wiring. Wiring shall be formed in a neat and systematic manner, with cables supported clear of panels and without crossovers. Bushes shall be provided as necessary to prevent chafing of cables. All wiring to instruments/equipment mounted on the hinged doors shall be run in flexible PVC conduits which are securely fixed and enclosed at both ends.

Each wire shall be terminated in crimped type of terminal studs. All wires associated with tripping circuits shall have red ferrules marked 'Trip'. Circuits of different Voltages and usages shall be kept physically separated and the working Voltages and service of each circuit shall be marked on the associated terminal boards.

All external wiring between the various switch panels, battery unit, and control panel shall be in Class '3' galvanized steel conduit to BS 4568 or in steel cable trunking to be carried out in a manner acceptable to the Engineer.

1.6 Cable Arrangement

Switchboards shall be located over the floor on channels and shall be designed for cables entering and leaving the switchboards vertically from above and/or below as appropriate.

Cable terminations shall be mounted adjacent to the associated circuit breakers and other associated equipment. The bottom and top sheets of the cubicles shall be sectionalized but vermin proof for bottom and top entry cables respectively. Entry plates shall be provided for entry cables. Where necessary, cables shall be supported in a folded channel with cable clamps. Cubicles shall be arranged to accommodate entries of all types of cables and gland plates.

1.7 Switchgear Arrangement

The Contractor shall provide the proposed switchboard layout drawings for the Engineer's review before fabrication of switchboard. Switchboard shall be arranged to suit the spaces available taking into consideration the necessary clearance for maintenance & servicing. Main Switchboard and Sub-Switchboard shall be constructed to Form 3B, Type 2 in accordance with BS EN 60439, busbar is separated from functional units and the terminals, but the terminals are not separated from each other.

1.8 Earthing

A suitable earthing terminal shall be provided on the frame of each section of the switchboard for connection to earth. An electro-tinned HDHC copper earth bar to be extended to the entire length of the switchboard shall be provided for earthing of all outgoing circuits and equipment frames.

1.9 Anti-Condensation Heaters

The switchboards shall be fitted with heating devices suitable for operating at 230-Volt AC single phase of enough capacity to raise the internal ambient temperature by 5 degrees Celsius. The electrical apparatus so protected shall be so designed that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the apparatus is in operation.

Heater 'ON' indicating lamps shall be provided and they shall always be wired to give true indication.

A suitable terminal box and control switch shall be provided & mounted in an accessible position for each switchboard.

1.10 Spring Charged Air Circuit Breakers (ACB)

Unless otherwise shown, the Air Circuit Breakers (ACB) shall be triple or four poles A.S.T.A. or K.E.M.A. certified for a fault rating of not less than that indicated on the Design Drawings at 500 Volt with a short time rating of 1 seconds generally in accordance with the requirements specified in IEC 60947-2 for circuit breakers.

The unit shall be spring charged, manually closed with ratings and instrumentation as specified and of the horizontal withdrawable type so arranged that it may be completely isolated from the switchboard except that secondary circuits shall not be broken with the circuit breaker in the 'test isolated' position in order to permit rest tripping or closing.

Closing mechanism shall be of push button action trip free type and the ACB shall be incorporated with mechanical indicators as following:

(i) Breaker status indicator as 'ON / OFF' (Closed / Open)

(ii) Spring status indicator as 'Charged / Discharged'

(iii) Breaker position indicator as 'Racked-in /Test isolated / Racked-out' or 'Connected / Test isolated / Disconnected'.

The indicators shall be mechanically and positively coupled to the operating mechanism and mechanically interlocked to ensure:

(i) ACB cannot be Closed unless it is in 'Racked-in' or 'Test isolated' position.

(ii) ACB cannot be Racked In or Racked Out unless it is 'OFF'.

(iii) ACB panel door cannot be Opened unless breaker is 'OFF'.

Contacts shall be adequately rated to ensure that they can carry continuously full rated current within the manufacturer's recommended temperature rise limits in the degree of protection specified and without damage or deterioration and shall be individually spring loaded, hard silver plated, of the magnetically 'blown out' type so arranged that electro-magnetic forces arising under short circuit conditions do not tend to produce contact pressure. Auxiliary arcing contacts shall be provided with renewable arc resisting alloy tips arranged to close before and open after the main contacts. Units shall be complete with primary and secondary isolating plugs and sockets, bolted type neutral link with provision of links for both transformer neutral earthing and connections, fixed busbar and feeder isolating contacts, screening shutters actuated automatically with the circuit breaker isolated and withdrawn and capable of padlocking in the screened position, arc chutes with baffle and splinter plates and efficient electro-magnetic arc control effective at all values of load current, including very low values, and magnetic blow out contactor 230 Volt AC shunt trip coil energized through relay contacts, auxiliary switches/relays/contacts for all necessary electrical interlocks including those associated with standby generators(if any), remote indication of 'ON', 'OFF', 'FAULT' status, etc. four (4) spare auxiliary contacts, independently adjustable for N/O or N/C shall also be provided for each circuit breaker. 'Close' and 'Trip' push buttons and red and green indicating lamps shall also be provided.

1.11 Moulded Case Circuit Breakers (MCCB)

Moulded case circuit breakers (MCCB) shall comply fully with IEC 60947-2 and the case shall be of moulded insulating material of good mechanical strength and non-tracking properties. The tripping mechanism shall be calibrated in compliance with British Standards at the factory and the breaker shall be sealed to prevent tampering.

MCCB shall be manual or automatic tripping operation as required. The automatic type shall each incorporate a trip unit to provide overload and short circuit protection. The trip unit for each pole shall provide inverse time delay under overload conditions and instantaneous magnetic tripping for short circuit protection. The trip units in all the circuit breakers shall be interchangeable. Earth fault protection shall be provided where called for in the Specification and Drawings.

The MCCB shall be so designed that when on tripped condition, the circuit breakers cannot be switched on again unless it has been reset by switching to OFF position first. The operation conditions (i.e. ON, OFF or TRIP) of the circuit breaker shall be clearly indicated.

MCCB shall be Double Pole (DP) or Triple Pole (TP) or four pole (4P) type as required. The construction and operation of the circuit breakers shall be such that if a fault occurs, all the poles of the circuit breakers shall operate simultaneously to isolate and clear the fault efficiently and safely without any possible risk to the operator or to the installation.

Each circuit breaker shall incorporate 'trip-free' mechanism to ensure that the breaker cannot be held closed in fault conditions.

The operating mechanism of the circuit breakers shall be hermetically sealed at the factory and all metallic parts associated with the operating mechanism shall be treated against rust and corrosion. The short-circuit breaking capacity of the MCCBs shall not be less than the maximum prospective short circuit current at the point where the MCCB is installed.

The Contractor shall be responsible for the selection and provision of the correct type of circuit breakers for protection of the types of circuits involved. The Contractor shall also be responsible for ensuring that the fuses where used in connection with MCCB shall coordinate with the circuit breakers to give proper protection and discrimination of the electrical system.

MCCB may be used in locations where the short-circuit current exceeds the breaker's established interrupting ratings provided suitable current limiting fuses are incorporated in the circuit breakers. The ratings of the circuit breakers and fuses must be carefully selected to prevent damage to the circuit breaker and to ensure coordination and high short-circuit protection required. The Contractor must provide the relevant data for review by the Engineer before the use of integrally fused MCCB's.

MCCB of frame size 100 Amp and above shall each be provided with extended operating handle with padlock facility.

1.12 Miniature Circuit Breakers (MCB)

Miniature Circuit Breakers shall be air-break type with automatic tipping mechanism (bimetallic device for over-current tripping and electromagnetic device for short- circuit instantaneous tripping), complying with IEC 60898. It shall incorporate a fixed time/current tripping characteristic calibrated in compliance to IEC 60898 at ambient temperature of 40 degree Celsius.

The mechanical and live parts except terminals and toggles shall be contained in a completely sealed casing of high mechanical strength materials. The toggle position shall be clearly indicated as "ON" and "OFF".

Double pole, three pole or four pole MCB shall be interlocked internally so that tripping on any phase will disconnect all poles simultaneously.

1.13 Relays

All relays offered for consideration shall be acceptable to the Engineer. The relays may be of the electro-mechanical or static transistorized versions or a combination of the two types.

Unless otherwise indicated, over-current relays shall be IDMTL (Inverse Definite Minimum Time Lag) type adjustable over-current setting 50% to 200% of rated values and adjustable time characteristic of 1.3/10 to BS 142. Direct acting instantaneous high-set elements shall be provided for the main circuit breakers of the

switchboards only. The earth fault relays shall incorporate adjustable definite time lag from 0 to 1.0 second and adjustable current settings from 5% to 40% in steps of 5%.

Relays shall be draw out, flush mounted in dust proof casings complying with B.S. 142 or equal. Relay cases shall generally be finished in black enamel.

Relays shall be arranged so that adjustments, testing and replacements can be affected with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case.

Electrically reset tripping relays shall be provided where necessitated by the system of control.

Relay contacts shall be suitable for making and breaking the maximum current which, they may be required to control in normal service but where the contacts of the protective relays are unable to deal directly with the tripping current, auxiliary contactors, relays or auxiliary switches shall be provided. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

Relays, where appropriate shall be provided with flag indicators, phase coloured where applicable. Flag indicators shall be of the hand reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case separate indicators shall be provided for each element.

Relays with provision for manual operation from outside the case, other than resetting, will not be accepted, and time delay relays shall not be of the dashpot type.

Relays, whether mounted on panels or not, shall be provided with clearly inscribed labels describing their application and rating in addition to the general-purpose labels.

Suitable means shall be provided on the relay panels for the testing of protective relays and associated circuits, withdrawable type cases and plug-in type test facilities being preferred.

Attention is particularly drawn to the humid tropical climate and relay designs should be entirely suitable for duty under these conditions.

To minimize the effect of electrolysis, relay coils operating on DC shall be so connected that the coils are not continuously energized from the positive pole of the battery.

Zone selective earth fault relays where called for shall be the solid-state zone selective interlocking type equivalent to Type ‘Z’ manufactured by General Electric each comprising a solid-state relay, ground sensor monitor panel, etc. of appropriate current rating to suit each application with adjustable trip current and time delay suitable for operation on 230 Volts, 50 Hz single phase AC supply. All zone selective earth fault relays selected shall be able to co-ordinate with both the upstream and downstream earth fault protection of the respective air circuit breakers and/or MCCBs. All necessary control cables, protection CTs, shunt trips accessories etc. for proper interlocking shall be deemed to be included in the Contract Sum.

The Contractor is required to submit proposal of protective relay co-ordination plan for the entire LV distribution network for review by the Engineer.

1.13.1 Earth Leakage Relay

Earth Leakage Relay shall comply with IEC 60255 and IEC 61000, incorporated with Zero Phase Current Transformers complying with IEC 61869 for activation of trip coil.

It shall be of tamper-proof design for protection of settings by high mechanical strength transparent cover. A manual test button and a reset button shall be provided for checking and resetting of relay operation. Earth leakage relay shall remain its tripping status until reset button is pressed.

Earth leakage relay shall be adjustable with current setting from 0.1A to 10A and time setting from 0s to 1s, with minimum 6 steps each.

1.13.2 Phase Failure Relay

A Phase Failure Relays is a type of control and monitoring relay which shall be designed to detect problems typically with a three-phase supply, however some can be used for single phase applications. The conditions which are monitored are Complete Phase Loss, Under Voltage, Over Voltage, Phase Sequence, Phase Asymmetry and Neutral Loss

1.13.3 Under Voltage Trip (UVT)

An under-voltage release device shall be installed in a circuit breaker to automatically trigger a power trip when the power falls below a preset level, usually between 70 and 35 percent of the UV rating. A UVT time-delay device shall be connected in order to present the time delay function as UVT is technically instantaneous type.

The closing of a circuit breaker is impossible mechanically or electrically if control power is not supplied to UVT. To close the circuit breaker, 65–85% of rated voltage shall be applied to both terminals of UVT coil.

1.14 Indicating Instruments

Meters for external panel mounting shall be of the flush pattern, with square escutcheon plates finished matt black and pressed steel cases. Indicating instruments shall be to B.S. 89 1st grade, moving iron spring controlled with 100mm diameter dials (230-degree scale) with external zero adjustment, integrating meters shall be to B.S. 5685 with cyclometer registers and protective relays to B.S. 142.

Voltmeters shall incorporate selector switches to enable phase to phase and phase to neutral Voltages to be read. Ammeters, being provided with selector switches shall be able to read all the line current. Generally, ammeters shall be scaled up to the rating of the incoming isolator/breaker; however, ammeters associated with motor circuits shall be 500% over scaled.

Instruments, meters and relays located on the front of the switchboard shall be segregated from the interior of the cubicle and so positioned that as far as possible, each instrument meter and relay is flush with the hinged dust proof access doors and is adjacent to the unit with which it is associated.

Meter panels shall be hinged to provide ready access to connections and small wiring shall be enclosed in flexible plastic conduit. All meters shall be fully tropicalized. All terminals shall be completely insulated, and potential circuits shall be suitably fused.

1.15 Automatic Transfer Switches

Automatic transfer switches shall be rated at 400 Volts of the current rating as shown on the Specifications Drawing, 4-pole type, electricity operated, mechanically held for automatic transfer from normal to emergency power supply when any phase of the normal power supply drops below 80 percent (but adjustable) rated Voltage frequency and re-transfer to normal power supply when the Voltage of all phases are 90 percent (but adjustable) or more.

Each automatic transfer switch shall be electrically and mechanically interlocked to prevent the normal and emergency contacts from closing simultaneously. The electrical interlock circuits shall be wired to operate from both normal and emergency power supplies.

The same mechanism connected with an Interlock, shall be for Automatic Transfer Switches installed where there are two (2) transformers feeding to two (2) DBs, to achieve transformer redundancy.

Each automatic transfer switch shall be capable as a whole of withstanding without damage the electrical, mechanical and thermal stresses produced under short circuit conditions at the prospective short circuit currents on the Design Drawings.

In-phase monitors shall be provided to sample the relative phase angle between the normal and emergency power supplies and shall signal the transfer switch to operate when the phase angle is at a predetermined value and approaching zero phase angle difference. The purpose of the in-phase monitors is to avoid high inrush currents and nuisance tripping during transfer and retransfer of motor loads.

Each transfer switch shall incorporate the following time delays:

(i) Time delay to override momentary normal power supply outages to delay the transfer switch and engine starting signals. The time delay shall be adjustable from 0.5 to 6 seconds.

(ii) Transfer to emergency time delay which shall be adjustable from 0 to 1 minute for controlled timing of local transfer to emergency power supply.

(iii) Unloaded running time delay for associated standby generator cool-down.

The time delay shall be adjustable from 0 to 5 seconds.

(iv) Retransfer from emergency to normal power supply time delay. The time delay shall be automatically bypassed if emergency power supply fails, and normal power supply is available. The time delay shall be adjustable from 0 to 30 minutes.

Each transfer switch shall incorporate the following manual controls, indicators, etc.

(i) Test switch to momentarily simulate failure of normal power supply.

(ii) Reset to normal switch for re-transfer to normal power supply during non- automatic operation.

(iii) Green and red indicator lights to indicate that the automatic transfer switch is connected to the normal and emergency power supply respectively.

(iv) 10 pairs of auxiliary contacts wired to terminal blocks within the switchboard for connection to the lift switchboards to initiate homing of the lifts when the transfer switch operates.

1.16 Interlocks

Each main distribution board shall be provided with complete interlocking facilities to provide the redundancy for transformers.

At an instance of a transformer (Incoming) failure the incoming circuit breaker shall be opened, and the bus section circuit breaker shall be closed, energizing the entire busbar from the second transformer.

The current rating of the interlock circuit breaker connected to the busbar shall be equal to the busbar current rating.

Interlocks shall be operated in each case as per the following criteria. Refer Design drawings for further information.

Cases	K1	K2	K3
Case 1 (Normal)	Closed	Open	Closed
Case 2	Closed	Closed	Open
Case 3	Open	Closed	Closed

1.17 Current and Voltage Transformers

Current transformers shall comply with SS 318 and IEC 61869 and Voltage transformers shall comply with IEC 61869. They shall be of suitable ratio, burden and class of accuracy for their function as indicated in the Design Drawings. Current transformers shall be capable of carrying a continuous overload of 120%.

Generally, all current transformers shall be of the ratio equivalent to the rating of the incoming isolator/breaker. Secondary windings shall be wired to suitable terminal boards and earthed at one point in the circuit.

All transformers shall be wired with an identifying label giving type, ratio, class, output and serial number.

Current transformers and Voltage transformers shall be provided with readily accessible test links.

1.18 LV Switchgear Auxiliaries

All other LV switchgear auxiliaries such as terminal boards, control switches and push buttons, auxiliary switches, indicating lamps, fuses and links, labels toolbox etc. shall be as specified under of the Specification for 'HV Switchgears and Auxiliaries'.

1.19 Surge Protection Devices (SPD)

Surge Protection Devices for main and sub switchboard shall be of Type 2, DIN-rail type, common mode protection complying with IEC 61643-1 and 11.

SPD shall have minimum discharge ratings of 65kA or as per Design Drawings and shall be provided by a dedicated miniature circuit breaker or HRC fuse that has been tested to coordinated with the manufacturer's SPD in accordance to IEC 60364.

SPD shall have a light indicator or mechanical indicator for end-of-life indication, linked to BMS system.

1.20 Indicating Lamps and Fittings

All indicating lamps shall be of transformer operated type. Indicating lamps fitted to the fascia of switch and instrument cubicles or panels shall be adequately ventilated. Lamps shall be easily removed and replaced from the front of the panel by manual means not requiring the use of extractors.

The bezel of metal or other suitable material holding the lamp glass is to be of good quality finish and to be easily removable from the body of the fitting to permit access to the lamp and lamp glass.

The lamps shall be clear and suitable for fitting to an accepted standard form of lamp holder. The rated lamp Voltage should be 10 Volts in excess of the DC supply Voltage. Alternatively, low Voltage lamps with series resistors will be acceptable.

The lamp glasses shall be in the standard colours, red, green, blue and white etc. The colour shall be in the glass and not an applied coating and the different coloured glasses shall be interchangeable. Transparent synthetic materials may be used instead of glass.

1.21 Auxiliary Switches

Enough numbers of auxiliary switches shall be provided in each switch panel of indication, protection, metering, control, interlocking, supervisory and other services specified. Auxiliary switches shall be wired up to a terminal board on the fixed portion of the plant, whether they are in use or not in the first instance.

All auxiliary switches and mechanisms shall be mounted in accessible positions clear of the operating mechanisms and shall be suitably protected. The contacts of all auxiliary switches shall be strong with a positive wiping.

1.22 Terminal Boards

All terminal boards shall be mounted in accessible positions and, when in enclosed cubicles shall be inclined towards the door. Spacing of adjacent terminal boards shall be not less than 100 mm and the bottom of each board shall be not less than 200 mm above the incoming cable gland plate. Separate studs shall be provided on each terminal strip for the cores of incoming and outgoing cables including all spare cores. Separate terminal boards shall be used for circuits of different Voltages and they shall be spaced/segregated to the requirements of the Engineer.

Brass bolts and studs shall be of not less than O.B.A. size but stainless steel and bronze down to 2 B.A. may be used provided that the current carrying capacity is adequate. All studs shall be provided with nuts, washers and lock nuts or lock washers. Where pinch type terminations are provided these shall be subject to review by the Engineer. These are to have adequate current carrying capacity and shall be provided with locking devices. Insulated carrier shall be fitted between adjacent terminals.

Terminals shall be fitted with non-inflammable transparent plastic covers to prevent contact with any live parts. They are to have warning labels with red lettering mounted thereon in a conspicuous position.

All connections shall be made at the front of the terminal boards and no live metal shall be exposed at the back.

1.23 Control Switches and Push Buttons

Control Switches for electrically operated circuit breakers shall be of pistol grip type arranged to operate clockwise when closing the circuit breakers and anti-clockwise when operating them. They are to be designed to prevent accidental operation and interlocked to prevent two successive operations in the ‘close’ direction.

Switches for the other apparatus shall be operated by shrouded pushbuttons or having handles of the spade type, the pistol grip type being reserved for circuit breaker operation only. Control, reversing selector and test switches shall be mounted, constructed and wired to facilitate the maintenance of contacts without the necessity for disconnecting wiring.

Control switches for circuit breakers and for motor operated setting devices, shall be of the non-locking type with spring return to the 'neutral' position. Such switches shall be controlled by independent springs, the use of contact springs alone for restoring not being acceptable.

All pushbuttons shall be of the non-retaining type made on non-hygroscopic material, non-swelling and fitted to avoid any possibility of sticking. All pushbuttons provided for remote stopping of motor control gear and all emergency trip pushbuttons shall be of the 'hold-in' type requiring to be reset by being pulled out, or by a separate release device which may be the associated 'start' push-button.

The contacts of all switches and pushbuttons shall be strong with positive wiping action when operated.

All control switches shall be provided with labels complying with the relevant section of this Specification in addition to clear indication as to the direction of each operation for example 'Open', 'Close', etc.

1.24 Fuses & Links

All fuses and links associated with electrical instrument, protection and control circuits shall be grouped as far as possible according to their functions. They shall be clearly labelled, both on the panels and the associated wiring diagrams.

Fuses and links shall be connected to enable all or any of the control circuits to be isolated for maintenance purposes.

Fuses and links associated with tripping circuits shall preferably be mounted on the outside of panels in suitable positions, whilst the remainder shall be mounted internally.

All fuses shall incorporate HRC cartridges Cat. 440/AC4 Class 'Q' to B.S. 88. Rewireable fuses will not be accepted. Carriers and bases for fuses shall be black. Link carriers and bases shall be white.

1.25 Motors & Control

All motors shall be in accordance with B.S. 2613 and B.S. 5000 and, unless otherwise specified, shall be suitable for single phase 230-Volt 50Hz operation and of the totally enclosed fan cooled type, rated for continuous operation and suitable for direct-on-line starting.

They shall be suitable in all respects for service in a damp tropical climate. Main conductor and slot insulation are to be non-hygroscopic and in accordance with Class F of B.S. 2757.

Motors shall be capable of operating continuously at rated output at any frequency between 48 and 51 cycles per second and at any Voltage within 6 percent of the nominal value. Motors shall be designed to operate for a period of not less than 5 minutes and at normal frequency without injurious over-heating.

The motors shall be capable of accelerating the driven load to full speed in a time in seconds not exceeding 0.25 times the rated B.H.P. plus 15.

All terminal boxes shall be fitted with a sealing chamber, conduit entry or adaptor plate as required together with the necessary fittings to suit the type of cable specified.

1.26 Labels

All cubicle doors shall be appropriately labelled to indicate the service. Labels shall also be provided to identify all items of equipment, circuits, cables and where applicable current rating of fuses and setting of relays. Labels on the exterior of equipment shall be clear Perspex, reverse engraved, filled flush with black (or red as

suitable) filling and the back painted the same colour as the equipment. Labels shall be attached by means of machine screws and nuts or machine screws driven into drilled and tapped holes.

1.27 Secondary Wiring

All secondary wiring shall be of 600/1000 Volt grade multi-strand copper conductors of not less than 2.5 sq. mm section insulated with PVC to B.S. 6231 and shall be grouped and fixed securely without strain by cleats of the compression type. For the purpose of identification different insulant colours shall be provided to distinguish the various circuits and each connection shall terminated at a terminal block placed in an easily accessible position for testing at site with coded acceptable ferrules at both ends of each conductor. Wiring between fixed and moving portion of the switch panel shall be so secured at both ends and covered in polyethylene spiral wrapping to prevent any damages to them when the panels are moving. No connectors or soldered joints shall be permitted in the wiring. The wiring shall be formed in a neat systematic manner, with cables supported clear of panels and without crossovers. Bushes shall be provided as necessary to prevent chafing of cables.

Each wire shall be terminated in crimped type of terminal studs. All wires associated with tripping circuits shall have red ferrules marked 'Trip'. Bus wire shall be fully insulated and run separately along the top or bottom of the panels. Circuits of different Voltages and usages shall be kept physically separated and the working Voltages and service of each circuit shall be marked on the associated terminal boards.

All external wiring between the various switch panels, battery unit, and control panel shall be in Class '3' galvanized steel conduit to B.S. 4568 or in steel cable trunking to be carried out in a manner acceptable to the Engineer.

1.28 Toolbox

A wall mounted lockable toolbox shall be provided in each Main LV Switch room to keep all the keys, special tools, logbook etc. associated with the switchgears. The toolboxes shall be constructed of aluminium frame with glass front complete with all necessary key/tool holders, labels etc. Three keys for each toolbox shall be provided.

1.29 Automatic Power Factor Correction Capacitor Banks

1.29.1 General

The contractor shall supply, deliver to site, test and commission the complete automatic static power factor correction capacitor banks which shall consist of but not limited to power capacitors, controllers, fuses, contactors, cabinets, cabling, networking, software, interface cards, gateway, personal computers, etc.

1.29.2 Power Capacitor Construction

All capacitors shall be of low loss type with a rated nominal Voltage as shown in the Design Drawings and comply with IEC 831-1 and 2.

The capacitors shall be designed to operate satisfactorily up to 150% of nominal current at rated Voltage and frequency (50Hz).

All capacitors shall be tropically rated in accordance with temperate class 25/D to be operated under the following ambient conditions:

- Minimum ambient temperate : 25 °C
- Average ambient temperature over 24 hours period : 45 °C

- Maximum ambient temperature : 55 °C

Energy loss in each capacitor bank shall not be more than 0.7W/kVAR and a discharge resistor shall be incorporated to reduce the residual Voltage to below 50V within 1 minute after disconnection of the capacitor bank from the mains.

The capacitors shall have an insulation level capable of withstanding 6kV at 50Hz for 1 minute and an impulse test level of 25kV for the 1.2/50 micro-second (µs) cycle.

All capacitors shall be dry type with metallized polypropylene film and possess self- healing properties. The use of Polychlorinated Biphenois (PCB) and oil as capacitive element is strictly prohibited.

Each element forming the three-phase capacitor bank shall be enclosed in a high thermal plastic enclosure.

Each element forming the three-phase capacitor bank shall be fitted with the following protection devices:

- HRC cartridge fuse
- Over-pressure disconnect device
- Built-in discharge resistor

The three phase capacitor banks shall be mounted on vertical plate. Each element of the three-phase capacitor shall be installed in horizontal position in order to improve natural cooling. All three phase capacitor banks shall have the same vertical dimension between fixing points.

The switching contactors shall be of adequate rating to withstand inrush and harmonic currents. Each contactor shall incorporate a pre-insertion block with inductor / resistor and an auxiliary contact designed to close before the main contacts, to reduce inrush current.

The vertical plate must also to be mounted with capacitive switching contactor and a set of three HRC fuses designed to provide protection to the three-phase capacitor bank.

1.29.3 Automatic Control

An electronic power factor controller shall automatically switch on the required number of steps according to the load, to maintain the power factor at the set value indicated by the controller. The controller controls the opening and closing of the capacitor switching contactors.

Each contactor-capacitor assembly is referred to as a capacitor step. The number of capacitor steps of switching operation shall be as indicated on the Design Drawings.

Each controller shall be equipped with a device that automatically disconnects all connected capacitors in the event of a power failure, over Voltage, over temperature or capacitor overload. When power is restored, the capacitors are re-connected according to system reactive power needs.

An alphanumeric LCD display shall provide on each controller to display the set power factor, the corrected power factor, the no. of energized steps, indication of alarm tripping, etc. The alarm shall be initiated when set thresholds are exceeded, which shall include loss of capacitance, capacitor temperature, overload current, total Voltage harmonic distortion, over Voltage, set power factor, etc. Dry contacts shall be provided for remote indication of alarm.

1.29.4 Detuning Reactors

Where indicated in the Design Drawings, detuning reactors shall be provided for capacitor banks installed in networks of high harmonic content. The Contractor shall be responsible to determine the most dominant harmonic and determine the value of the reactors to detune the circuit to prevent high harmonic currents.

1.29.5 Enclosures

Enclosures complying with BS EN 60439-1 shall be provided to house the capacitor banks, contactors and other protection devices and controllers.

All automatic compensation equipment shall be capable of withstanding for 1 minute a test Voltage of 2.5kV at 50Hz. The minimum degree of protection for the enclosures shall be IP31. Force fan cooling shall be provided for cabinet having total capacitor rating exceeding 200 kVAR.

Each enclosure shall be provided with a main incoming MCCB of rating like the feeder circuit.

1.30 Tests

1.30.1 Factory Tests of Main Switchboard and Sub-switchboard

Prior to dispatch the Main Switchboard and Sub-switchboard out of the factory, each panel of the switchgear shall be tested in the presence of representatives of the Employer and all cost associated shall be deemed included in the sub-contract. The factory tests to be performed shall include the below tests and other tests as recommended by the IEC standards and manufacturer:

(i) Functional Tests to confirm the functions of the electrical control, interlock, local/ remote selector, Circuit Breaker indicator at rated control Voltage. The wiring of control and protection circuit shall be checked against the relevant control wiring diagram.

(ii) Mechanical operation tests to confirm smooth operation of circuit breaker trip / close, spring charge. To confirm the mechanical interlock of circuit breaker for a minimum of 5 times.

(iii) Key interlock and electrical interlock tests for the couplers.

(iv) Primary Injection Tests to verify the polarity, correct CT ratio and measurement of secondary meter reading.

(v) Secondary Injection Tests to confirm the relay operations.

(vi) Contact Resistance Tests to confirm the resistance of busbar including the circuit breaker and the busbar and cable termination for each panel.

(vii) Power Frequency Voltage Test.

(viii) Dielectric Test on auxiliary and control circuit, insulation resistance shall be measured before and after the test.

Prior to delivery of transformer to site, the Contractor shall carry out a site survey and make all necessary co-ordinations with the Main- contractor as regard to access for the safety transportation of transformer to the designated location.

Each panel of the switchgear shall be labeled as required by the Owner.

1.30.2 Site Test

a. The Contractor shall provide all the necessary testing equipment to perform all site testing and commissioning.

b. In addition to the tests required by the Local Authority and those recommended by the Manufacturers, the following tests shall be carried out.

(i) Insulation Resistance Test.

(ii) Functional Test

(iii) Mechanical operation test.

(iv) Dielectric Test

2. LV Mains & Sub-Mains Distribution

2.1 General

The works covered in this section is for the supply, installation and connection of LV mains and sub-main cables, cable risers, busduct system as detailed in this section, including all necessary materials, terminations to form a complete installation.

All works to be performed under this section shall be in accordance with the current edition of Code of Practice, relevant standards and rules & regulations currently in force in Indonesia.

The maximum Voltage drop from the origin of the installation and the fixe current using equipment shall not exceed 5% of the nominal Voltage of supply or as stipulated by the local authority.

The installation of the mains and sub-mains shall be carried out in accordance with the specified requirements for each type of cable. The cables shall be routed underground or in cable trenches, ducts, trunkings or conduits or ladders or trays as shown on the Design Drawings and/or detailed in this Specification.

The cable routes and cable ducts where shown on the Design Drawings are for general guidance only and the Contractor shall be responsible to check and ensure the feasibility of these routes and adequacy of the cable ducts by submitting detail dimensional drawings of all items of equipment and make any necessary modifications/alterations to suit the site conditions and to the satisfaction of the Engineer.

Vertical metal framing/supporting system similar to 'UNISTRUT' or equivalent shall be erected in the vertical risers to facilitate installation of cables, busbar trunkings, cabling trunkings, trays, ladders, etc. Details of the framing/supporting system shall be submitted to the Engineer for review. Also, mockup shall be constructed if required by the Engineer.

Conductors of less than 1.5 sq. mm cross-sectional area shall not be used in mains Voltage circuit.

2.2 Cable Codes

Where applicable, the following abbreviations are cable codes used in this Specification and Drawing:

(i)	PVC	Polyvinyl chloride insulated
(ii)	PVC/PVC	Polyvinyl chloride insulated and polyvinyl chloride sheathed
(iii)	PVC/SWA/PVC	Polyvinyl chloride insulated, single steel wire armoured and polyvinyl chloride sheathed
(iv)	XLPE	Cross linked polyethylene insulated
(v)	XLPE/PVC	Cross linked polyethylene insulated, and polyvinyl chloride sheathed
(vi)	XLPE/SWA/PVC	Cross linked polyethylene insulated, single steel wire armoured and polyvinyl chloride sheathed
(viii)	FR	Fire retardant/Self-extinguish
(v)	LSZH	Low Smoke Zero Halogen

2.3 PVC & PVC/PVC Cables

PVC & PVC/PVC cables and PVC/PVC flexible cords shall be of 450/750 Volt grade comprising high conductivity stranded copper conductors of sizes shown on the Design Drawings, to BS 6360, PVC insulated, and PVC sheathed to SS 79 or BS 6746 and manufactured to SS 358 for PVC insulated, non-sheathed cables and to IEC 502 for PVC insulated PVC sheathed cables. Insulation colours shall be in accordance with the current edition of IEC 60364: Electrical Installations in Buildings (BS 7671).

PVC cables shall be routed in conduits and/or trunkings.

PVC/PVC cables shall be routed at high level on proprietary make horizontal cable trays or ladders and support system like UNISTRUT or equivalent system. All vertical runs including cable to switchboards, etc. shall be secured on cable ladder system like BICC VANTRUNK or equivalent system. For horizontal runs, PVC/PVC cables shall be secured neatly on the cable trays or ladders at close intervals by means of moulded polythene cleats like BICC 'Telcleat' or other equivalent whereas claw cleats shall be used for securing vertical cables. Fixing shall be made with rawlbolts or other patent fixing devices of design to be reviewed by the Engineer. Details of cables routes, terminations and support system shall be forwarded to the Engineer for review prior to installation.

PVC and PVC/PVC cables shall be terminated in suitable sizes tinned copper compression connector to relevant BS standard requirements.

2.4 XLPE and XLPE/PVC Cables

XLPE and XLPE/PVC shall be of 600/1000 Volt grade comprising high conductivity stranded copper conductors manufactured and tested in accordance with SS 324 or BS 5468. The PVC sheath for XLPE/PVC cables shall be in accordance with SS 79 or BS 6746.

For XLPE and XLPE/PVC cables, the installation details and method shall be same as those specified elsewhere in this Specification for PVC and PVC/PVC cables respectively.

2.5 PVC/SWA/PVC Cables

All PVC/SWA/PVC cables shall be of 600/1000 Volt grade manufactured and tested in accordance with BS 6346.

Jointing of PVC/SWA/PVC steel wire armoured cables shall be carried out by accredited and fully experienced jointers and evidence of this shall be produced to the satisfaction of the Engineer before jointing is started.

At terminal sealing boxes, cable cores shall be carried through unbroken to apparatus terminals and cores shall be sweated solid where they pass through cast resin.

All joints which are buried in the ground shall be compound filled. The design of the box and the composition shall provide an effective seal to prevent moisture gaining access to the conductor ferrules and armour clamps.

Provision shall be made for earthing the wire armour to the main earth electrode at the supply end by means of a metallic bond of adequate conductance, and the bonding connection should be as short and straight as possible.

The wire armouring shall be maintained electrically continuous and careful attention shall be paid to the design of all bonding clamps in joints and terminations to ensure that the resistance across a clamp is not higher than that of the equivalent length of the complete wire armour of the cable. The conductance of the

carcase of the cast iron box is normally enough for this purpose but where it falls short, an auxiliary metallic bond shall be included.

Compression type glands for the termination of PVC/SWA/PVC cables shall be included with the termination boxes supplied under this Contract. Marshalling and other terminating boxes supplied under this Contract, however, are to include the cable terminating glands.

The design of compression glands is to be such that the cable is not twisted when the gland is tightened. They are to provide facilities for the efficient bonding and termination of the armour wires and are to project at least 20 mm into the terminating box so that any condensation collected on the inner surfaces of the boxes cannot flow down between the cable cores. Where anti-condensation heaters are not fitted, drain holes are to be provided. It is to be possible to effect and dismantle any cable compression gland without the use of special tools.

2.6 XLPE/SWA/PVC Cables

XLPE insulated single steel wires armoured and PVC sheathed cables (XLPE/SWA/PVC) shall be of 600/1000 Volt grade comprising of high conductivity stranded copper conductors manufactured and tested in accordance with SS 324 or BS 5468.

The installation details and method shall be same as those specified elsewhere in this Specification for PVC/SWA/PVC cables.

2.7 FR LSZH Cables

Fire retardant LSZH cables shall be of 600/1000 Volt grade comprising high conductivity copper conductors, insulated with an extruded thermoset flame retardant and fire resistant, moisture proof compound and overlapped with a copolymer coated aluminium strip extruded with a special flame-retardant PVC outer jacket. The cable insulation and sheath (where used) shall be of halogen free material tested in accordance with IEC 60754-2. All fire-resistant cables shall comply with Category CWZ of BS 6387 and tested to BS EN 60332-3 and shall be approved by the Local Authorities for use as fire resistant cables related to emergency power supplies.

FR LSZH Cables shall be complied with BS 6387 Category CWZ 950 degree C and tested to BS EN 60332-3.

In addition, the cables shall be flame resistant to BS 6387 (minimum category B), and flame retardant to BS 7211 and be tested to BS EN 60332-3. The electrical and mechanical properties of the cable shall comply with BS 6387 (minimum Category Y).

Test certificate from relevant testing authorities to substantiate compliances of the cables with BS 6387 shall be submitted to the Engineer.

FR LSZH cables shall be installed in accordance with the maker's recommendations and instructions. FR LSZH cables shall be run on proprietary make cable trays, conduits, trunkings or cable ladders depending on the sizes of the cables.

All installation accessories shall be of manufacturer's standard products. Cable glands shall be of fire rating equal to the cable. The bending radius of the cables measured from the inside of the bend shall be not less than eight times the diameter of the cable.

2.8 Erection of Cables

Rates for erection of cables shall include the following

(i) All measuring, marking off and cutting to length.

(ii) Temporary sealing of cable ends where necessary and testing of cuts ends prior to connection.

(iii) Supply, delivery and erection of all racks, clamps, saddles, trays, supports, framing systems, bushes and other items required for erection and fixing of cables including excavation where necessary.

(iv) Design, provision, erection and painting of all additional supporting steelwork.

(v) Sheath bonding in the case of single core cables including supply of necessary materials.

(vi) Forming of necessary bends, surface fixing at intervals and phase identification of cores by suitably coloured PVC sleeving.

(vii) Sealing of cables in pipes or ducts where called for tests at site on completion including continuity, phasing out and insulation resistance between conductors and sheath employing a 500V 'Megger' tester.

In the vertical risers/ducts, all cables passing through floors shall be sealed effectively with suitable material of 2 hours fire rating to the approval of Building Authority and the Engineer.

All cables shall, where they pass through floor or otherwise in such positions vulnerable to damage by mechanical or other means be protected by short length of steel pipe suitably bushed to prevent abrasion of the cable.

2.9 Jointing

The Contractor is to be wholly responsible for the sealing and jointing of all cables erected and jointed under this Contract.

Cable sealing and jointing is to be in accordance with the best current practice and of first-class workmanship. Where cable sheaths are used as earth continuity conductors, glands are to have the necessary contact surfaces or straps to provide a low resistance path under fault conditions.

The cost of all jointing materials for the termination of cables into sealing boxes attached to equipment supplied under other contracts is to be included in the prices for jointing into these boxes.

A record is to be kept of all joints and terminations made and is to include the name of the jointer and mate, the date of testing and the weather conditions prevailing. Three copies of this records signed by the Contractor shall be supplied to the Engineer.

Straight joints in any of the cables installed under his Contract will only be permitted in very exceptional circumstances and only with the Engineer's consent in writing. The cost of such straight joints, if permitted by the Engineer, shall be borne by the Contractor.

2.10 Underground Cable Installation

2.10.1 Excavation of Trenches

The excavation of trenches shall include, by way of Amplification but not of limitation, all timbering, pumping and baling required and the provision of all necessary labour, plant, tools, additional soil, fuel and motive

power for such purposes and the cost of this service and of the supply of expendable materials shall be included in the Contract Sum.

All trenches shall be of sufficient width to enable the following minimum spacing between cables to be maintained:

- Between HV & LV cables - 300 mm
- Between LV cables - 75 mm
- Between HV & ELV cables - 1,800 mm
- Between LV & ELV cables - 300 mm

Before the cables are laid, the bottom of the trench shall be lined with sifted soil which is to be punched down to a thickness of 50 mm to form a bed. After the cables are laid, the first 75 mm depth of cover back fill shall consist of sifted soil over which shall be placed protective covers.

2.10.2 Backfilling and Reinstatement

After all cables and protective covers have been laid, the trenches shall be refilled in 150 mm layers, each layer being well rammed and consolidated.

The surface of refilled trenches shall be temporarily reinstated and maintained in a thoroughly safe condition until complete consolidation of the solid is achieved.

The Contractor shall supply backfill materials necessary for the replacement of unsuitable excavation material and the cost of this material together with the backfilling, reinstatement and removal of surplus material shall be included in the Contract Sum.

The Contractor shall include for all materials and labour to reinstate the ground to the same condition as existed prior to excavation.

2.10.3 Cable Covers & Markers

Protective cable covers shall be of reinforced concrete and shall be 900 mm long, 150 mm wide, and 50 mm thick. They shall be arranged for interlocking one with the other both vertically and laterally.

Plain flat concrete cable markers minimum size 460 mm by 100 mm thick shall be provided and installed with the top surface flush with ground level to identify cable routes of cables laid direct in the ground. Markers shall be inscribed with indented lettering reading LV cables.

2.10.4 Cable Identification Tags

All cables shall be identified at both ends by lead labels with 5 mm (3/16 inch) high (minimum) stamped cyphers securely wired on to the tinned copper wire.

2.11 Sealing & Drumming

Immediately after works' tests, both ends of every cable length shall be sealed by means of suitable metal caps. The ends of the factory lengths are to be marked 'A' and 'Z' in accordance with BS 6480 Part 1.

The cable end projecting from the drum is to be adequately protected to prevent damage during handling and in transit, and a thick PVC wrapper shall be placed over the cable to prevent the ingress of dirt, dust and grit etc.

Cable drums shall be lagged with closely fitting battens. Each drum is to bear a distinguishing number which is to be branded with hot irons or neatly chiseled on the outside of one flange. A painted identification number will not be accepted.

2.12 Tests During Laying

Where required by this Specification, and as required from time to time by the Engineer, the Contractor shall subject completed portions of the cable installation to Voltage tests to prove the soundness of the conductor insulation and the protective servings.

2.13 Cable Pulling

Winching of cables through ducts shall only be carried out with a pulley eye attached to the conductors.

A cable sheath stocking may be employed on cables where no undue stress in the sheath is likely to occur.

Care shall be taken to ensure that the draw strain is applied to the armouring and that the armouring and serving are protected during drawing against damage.

2.14 Test Certificates from Manufacturers

The Contractor shall submit to the Engineer for review, prior to dispatch of cables from the place of manufacture, test certificates in respect of all cable supplied under this Contract.

2.15 Cable Record Drawings

Cable Record Drawings or 'As-Installed' Drawings showing the exact route of cables and positions of all joints, etc. shall be submitted for the Engineer's review.

2.16 Cable Trays

All cable trays shall be manufactured from perforated epoxy coated electro-galvanized mild steel of not less than 1.5 mm thickness for tray widths less than 450mm and not less than 2mm thickness for tray widths of 450mm and above. Copper links of appropriate cross section shall be provided from section to section to maintain earth continuity for cable tray.

Trays shall have upturned flanges on both sides of 20 mm deep for tray widths less than 450mm and not less than 25mm for tray widths of 450mm and above and shall be complete with all necessary standard long radius bends etc. and fixing brackets proprietary fabricated from galvanized steel channels etc. or frame system similar to UNISTRUT.

Coating Thickness shall be as per EN ISO 1461.

Thickness of the Metal	Minimum Mean Coating
Greater than 6 mm	85 microns
Greater than 3 mm	70 microns
Greater than or equal to 1.5 mm	55 microns
Less than 1.5 mm	45 microns

Heavy duty deep flange cable trays shall be joined by specially designed couplings to provide a strong continuous structure at joints and rigidity.

Trays shall generally be supported by directly bearing onto the top side of the concrete rib construction forming the ceiling and, in this event, only, a simple and efficient clamping arrangement to the ribs shall be effected to prevent lateral displacement of the tray. Unless otherwise stated, the tray shall be supported at not more than 1-meter intervals.

The whole of cable tray installation is to be provided with all necessary proprietary factory-made bends, risers, reducers, tees, crosses, drop-outs, etc. and any site fabricated items will not be allowed.

2.17 Cable Ladders

All cable ladders shall be of heavy-duty type manufactured from epoxy coated electro-galvanized mild steel of not less than 2mm thickness similar to BICC Vantrunk or equivalent.

Cable ladders should have a minimum 120mm high longitudinal side members and minimum 50mm wide rungs with slots of 63mm x 12mm covering the whole length of the rungs. Each cable ladder shall be in 3m length and supplied complete with coupling sets consisting of fishplates, splinted bolts, nuts and locking washers.

The whole of the cable ladder installation shall be provided with all necessary proprietary factory-made elbows, risers, reducers, tees, crosses, drop-outs, etc. and any site fabricated items will not be allowed.

Cable ladders shall be supported from roof/sidewall using frame system similar to UNISTRUT.

16 sq. mm copper jumpers shall be installed from section to section.

Coating Thickness shall be as per EN ISO 1461. Coating thicknesses shall be the same as cable trays. Refer table above.

2.18 Cable Trunkings

Cable trunkings shall be manufactured from epoxy coated electro-galvanized mild sheet steel. The thickness of the body and cover shall be in accordance with Table 1 of SS 249 or BS4678 Part 1.

The trunkings shall be complete as required with standard bolted flanged outlets, blank ends, reducers, outlet bushes, bends, tees, sleeve couplings, intersection four-way boxes and fittings adaptors of the same manufacturer. Bridge pieces to act as cable retainers shall be readily removable, but positive fixing by machine screws for the covers shall be provided. The inner radius of any bend shall not be less than 2.5 times the minor dimension of rectangular section trunking.

A copper link shall be provided on both sides of every trunking joint to provide earth continuity.

Trunkings shall be supported adequately by suitable brackets fabricated from galvanized mild steel angles.

Vertical runs of trunkings within electrical riser ducts which pass through floors must be provided with 2 hours fire resistant barriers inside and around the trunking. These barriers should consist of fire rated material cut way to enable the cables to pass through. Similar fire barriers shall be provided for cable trunkings passing through fire rated walls. Cable retainers shall be provided for all the cable trunkings. The type of cable retainers to be adopted shall be subject to review by the Engineer.

Cables for lighting and power circuits shall not be run in the same trunking as the cables for extra low Voltage circuits unless they are segregated effectively by means of a rigidly fixed metal barrier or screen. Wiring for emergency lighting shall be run exclusively in separate trunkings. Trunking runs shall be erected complete before any cables drawn in and the number of cables installed shall be such that a space factor of 45% is not exceeded.

All cut edges shall be anti-rust treated and all trunkings shall be painted with two finishing coats of good quality orange paint or any other colour paints to be advised later by the Engineer.

2.19 Conduit Installation

All conduits, fittings and accessories where run on surface galvanized steel complying with BS 4568 shall be. Conduits shall be screwed and welded Class “3” for Fire related services Class “4” and fittings shall be manufactured from steel or malleable cast iron.

UPVC conduits may be used in areas where they are concealed in walls, columns or floors. However, in cases where part of the conduit system is run on surface and the remaining part run in concealed position, then the entire run of the conduit shall be of galvanized steel including those parts which are concealed, in order to assure an electrically continuous system.

UPVC conduits shall be of heavy-duty type manufactured to BS 6099 and the accessories shall be manufactured to BS 4607. The system shall be halogen free, has low smoke density under fire, flame-retardant and impact resistant. Permanent adhesive shall be used for all joints and terminations to provide a rigid watertight joint. For long conduit runs or where structural/movement is anticipated, a non-hardening adhesive shall be used in conjunction with expansion couplers. Appropriate bending springs shall be used for bending of uPVC conduits where recommended by the manufacturer.

All GI conduits and accessories shall be painted with one coat of red lead wherever the exposed galvanized surface has been cut or otherwise damaged including exposed threads and connections after erection.

Conduits shall be properly and tightly screwed into the full depth of box spouts and butted in sockets between lengths to ensure maximum mechanical strength and electrical continuity so that the wiring is continuously and effectively protected throughout its whole length and is not in any way under mechanical stress.

The whole of the conduit system shall be electrically continuous throughout and in addition a separate circuit protective conductor shall be provided in all conduits. Further, all conduits shall be earthed at terminations.

Conduit sizes shall be selected carefully for the number and sizes of cables they are to contain and conduit shall be arranged with an adequate number of boxes, accessible for the life of the installation so as to allow easy draw in or draw out of any one or all of the cables at any time and shall not in any circumstances be less than 20 mm diameter and cables drawn in shall not be greater than the appropriate number permitted in the current edition of IEC 60364 : Electrical Installations in Buildings (BS 7671).

Cables for low Voltage circuits shall not be drawn into the same conduit for extra low Voltage systems. In addition, lighting and power final circuits shall be run in separate conduits except, where an adaptable box is employed as a final distribution point, a number of final circuits may be grouped together in larger conduits between the distribution board and the adaptable box provided that all circuits in one conduit are of the same phase; in the case of three phase circuits all three phases and neutral of any circuit should be draw into the same conduit. Wiring for emergency lighting shall be run exclusively in separate conduits.

Where condensation is likely to occur in surface conduits, they shall be laid with falls to drain off condensed moisture without entry into terminations. Provisions shall be made where necessary for leading the drainage away from outside walls, ceilings, fittings and accessory boxes and collecting spots and small-bore tubing may be used for this purpose.

The inside surface of all conduits and fittings used in connection therewith shall be smooth and free from signs of corrosion, burrs and all other defects. The ends of conduits shall be cut square, filed and reamered out after screwing and care shall be taken to ensure removal of cutting oil and swarf.

All corners shall be turned by easy bends or sets made cold on bending machines without deformation of the section of the conduit or opening of seams and the inner radius of any bend shall not be less than 2 ½ times the outside diameter of the conduit. Where it is impracticable to set the conduit, normal or half normal bends

may be permitted but in no circumstances shall be solid or insertion elbows or 'tee' pieces be used in a concealed position.

All switches, socket outlets, accessories and other fittings shall be mounted in conduit boxes of suitable size and where for reasons of construction the box face is not reasonably flush to the finished surface of wall or ceiling, purpose made extension rings of the same construction and diameter as the box shall be employed.

When conduit terminates at a metal base, distribution board, adaptable box, motor starter, terminal box or other fitting not provided with screwed E.T. conduit entry, a socket shall be screwed to the end of the conduit and a smooth bore male brass bush screwed into the socket entered from inside the metal case which shall be drilled with a clearance hole for the bush. The end of the conduit should butt together with the bush after the bush has been pulled up tightly against the inside of the case.

Where looping junction boxes are used for lighting points, outlets, etc. they shall be circular pattern with an appropriate number of back outlets. Conduits shall be terminated in these boxes by means of screwed sockets and male brass bushes as specified above. Ceiling boxes shall be standard circular deep pattern with long internally tapped spouts.

Conduit terminations to apparatus subject to vibration or movement shall be made off in flexible metallic conduit which shall be heavy gauge, weatherproof type PVC coated overall and sweated into heavy brass adaptors with a male thread for connection to the rigid conduit system at each end. Reliance shall not be placed upon the flexible tubing as an earth conductor and bare tinned flexible copper wire of not less than 1.5mm^2 shall be run inside and connected to the equipment earth terminal at one end and isolating switch earth terminal at the other end.

All boxes shall be fixed securely to walls, ceilings, etc., by means of at least two screws correctly spaced and all conduit runs shall be straight and run either horizontally or vertically; diagonal runs will not be permitted.

Conduit work and accessories where not concealed shall be fixed effectively by means of heavy pattern spacing saddles to hold off the conduit from the surface. Metal or other non-disintegrable plug of proprietary manufacture shall be used for fixings.

On straight runs the conduit shall be supported by saddles at intervals not exceeding

900 mm in addition to supports provided by structure, box or fitting included in the run except that for 32 mm conduit and larger, saddles may be spaced at intervals of not more than 1200 mm apart.

Bends must in all cases be supported on each side by two saddles as near thereto as possible and a draw-in box shall be provided after two bends and after not more than each 9 meters of straight run.

Where conduits are or may be in contact with steelwork of any description an efficient and permanent metallic bond shall be made between conduit and steelwork.

Where conduits cross expansion joints they shall be installed so as not to resist relative movement of the sections.

Immediately on completion of erection of any conduit during building construction, all exposed conduits and boxes shall be plugged effectively against the ingress of water and dirt particularly where concrete will be poured. Such seals shall be maintained in good order for such time as is necessary to complete wiring and connection of fittings and switches.

On completion of erection, the conduits will be inspected by the Engineer and may be tested at his discretion by ball or plug gauge before any wire is drawn in. All conduits shall be swabbed out and free from moisture to

the Engineer's satisfaction before wiring is commenced; draw in tapes with absorbent cloth, such as winceyette, flannel or army pull through cloth, shall be used for this purpose.

On completion of the installation, all exposed conduits shall be painted with two coats of good orange paint or any other colour paints which may be advised later by the Engineer.

2.20 Fixings

Necessary fixings for all fittings, switches, socket outlets, cables, cable trays, cable trunkings, etc. shall be supplied and erected under this Contract as follows:

(i) In woodwork by appropriate size of woodscrew.

(ii) In brickwork or concrete by appropriate size non-shrinkable rawlplug and sherardized round head wood screw.

(iii) On steel work by proprietary made galvanized girder clip.

No drilling of structural steel work will be permitted except as reviewed by the Engineer.

2.21 Fire Barrier and Fire Rating

All cables, cable containment system such as trunking, cable trays, cable ladders, etc. that passes through the Fire Compartmentation shall be sealed with Fire Rated Materials tested and approved by Local Authorities such as Fire Resisting Barriers of the approved fire rating not less than the Fire Compartmentation in that space/area as per approved Fire Plan Submission. Necessary approved fixings for all accessories, etc. shall be supplied and included. The fire resisting barrier will intumesce and will expand to seal gaps under heating by fire.

2.22 Site Tests

The following site tests shall be carried out on the LV main switchboard and LV cables,

(i) Functional Tests to confirm the functions of the electrical control, interlock, local/ remote selector, Circuit Breaker indicator at rated control Voltage. The wiring of control and protection circuit shall be checked against the relevant control wiring diagram.

(ii) Mechanical operation tests.

(iii) Key interlock and electrical interlock tests for the couplers.

(iv) Primary Injection Tests to verify the polarity, correct CT ratio and measurement of secondary meter reading.

(v) Secondary Injection Tests to confirm the relay operations.

(vi) High Voltage pressure test for 1 min.

(vii) Insulation Resistance Test.

(viii) Dielectric Test

(ix) Earth Loop Impedance Test.

(x) Polarity Test

(xi) Continuity Test

3. Distribution Boards

3.1 Type & Construction

Each distribution board shall comply with BS EN 61349, type tested and shall be fabricated from 14/16 s.w.g. sheet steel, bonderised and finished in grey stove enamel outside to colour 631 of B.S. 381C and matt white inside complete with hinged cover, the free end of which shall be secured by captive knurled thumb screws and chrome-plated lockable handle, gaskets, solid type concealed hinges, detachable undrilled end plates fitted top and bottom and external wall fixing lugs arranged to provide a small air gap between the back of the board and the wall.

Distribution board shall be completely enclosed in dust, insect and vermin proof units housing MCB's, MCCB's, contactors, electro-tinned busbars, fuses, fuse bases, time switches and carriers and all necessary items of equipment whether specified herein or not, suitable for indoor service in ambient environment as specified elsewhere at maximum continuous rating without exceeding the maximum temperature permitted by the relevant B.S. specification for operation on 400/230 Volt 3 phase 50 Hz system with solidly earthed neutral. All distribution boards shall be manufactured to withstand, as a whole, the electrical, mechanical and thermal stress that could be produced by the prospective fault levels at their respective points of application.

Special attention shall be given to insulation and finishes of all items and no linseed oil varnished, presspahn, fibre or hygroscopic materials shall be used in any position and all components shall have a tropical finish including electro-tinning of non-ferrous parts and vacuum impregnation of operation coils.

Distribution boards shall be slim and compact of proprietary make similar to G.E, Westinghouse or equivalent and shall so far as possible utilize standard sub-base assemblies and frames of standard dimensions in depth, length and height and the front shall present a flush, clean appearance. Additional space shall be allowed in each distribution board for increasing the no. of circuit way specified in the Design Drawings by at least 20% and suitable blank plates shall be provided for the initial installation.

Each distribution board shall incorporate an integral manually operated incoming moulded case circuit breaker and/or residual current circuit breaker to enable all live parts to be made dead with the switch position at 'off' from the front. All live parts shall be suitably shrouded so that there is no possibility of accidental touch when the panel is open. The neutral shall be linked by means of a removable bolted HDHC copper link.

Fuse bases and carriers where used shall be of glazed porcelain or other non-hygroscopic insulant suitable for the reception of HRC fuses and each bank of fuses is to be arranged for easy removal. Fuse carriers shall be so designed that it is impossible for 'live' metal parts to be touched when the carrier is being inserted or withdrawn regardless of how it is being held.

Each distribution board shall be complete with a neutral bar of square or rectangular cross section having two pinch grip screw terminal connections for each single-phase way in the board and for conductors larger than 2.5 sq. mm cross sectional area, cable sockets or four screw cable clamp pattern terminations shall be used. The neutral bar provided in each distribution board shall have adequate number of terminals.

Where applicable, contactors and time switch for lighting control shall be mounted in a separate compartment, with removable hinged covers, fixing screws within the same cabinet as the sub-circuits. Protection fuses for the contactors and/or time switch shall be neatly arranged and labelled for easy identification. Similarly, the terminal strips for remote wiring shall be clearly identified.

All contactors, time switches, cable sockets, busbars, insulators, phase colouring, labels and indicating lamps shall be included as shown on the Design Drawings and as required for satisfactory performance whether stated herein or not all shall comply with the appropriate clauses of this Specification.

Single-line schematic diagrams of the various distribution boards are shown on the Design Drawings.

A brass earthing terminal shall be provided of size not smaller than O.B.A. for maximum size of incoming cable up to and including 100 Amps, and not less than 3.5mm for incoming cables above 100 Amp. The earthing terminal shall be provided with brass washers, brass nuts, and cable lug. A brass earthing bar similar to the neutral bar specified above shall be provided and shall be linked to the earthing terminal.

Incoming cable terminals shall be provided at one end of the busbar or busbars, as required, arranged so that it is impossible to cause them to come into contact with one another or with the enclosure. Terminals shall be of the pressure clamp or soldering socket type, and shall be such that all strands of the cable may be securely contained. The phases of the busbars shall be identified by colour PVC sleeves or proper painting.

Each distribution board shall be so arranged that all connections are easily accessible from the front of the board. Adequate space shall be provided for out-going circuit wiring so that the cables will be required to pass between the back of the enclosure and the busbars/circuit breakers. All cables shall be bundled by means of nylon self-locking cables ties and fixed in a neat and systematic manner.

The constructions of the distribution boards shall be such that no cable is subjected to a bend of internal radius less than four times the overall diameter of the cable.

Each distribution board shall be provided with a label of laminated plastic, black, engraved in white with the words: DISTRIBUTION BOARD followed by the reference designation as the case may be in characters at least 6mm high, attached by screws or reverted to the outside of the cover.

A schedule of circuits shall be provided in printed form on paper or card and mounted behind transparent plastic on the inside of the hinged door.

Distribution boards shall be mounted generally at 1500 mm from the centre line to the floor level.

3.2 Moulded Case Circuit Breakers (MCCB)

Moulded case circuit breakers shall comply fully with B.S. 4752: Part 1 and the case shall be of moulded insulating material of good mechanical strength and non-tracking properties. The tripping mechanism shall be calibrated in compliance with British Standards at the factory and the breaker shall be sealed to prevent tampering.

Moulded case circuit breakers shall be manual or automatic tripping operation as required. The automatic type shall each incorporate a trip unit to provide overload and short circuit protection. The trip unit for each pole shall provide inverse time delay under overload conditions and instantaneous magnetic tripping for short circuit protection. The trip units in all the circuit breakers shall be interchangeable. Earth fault protection shall be provided where called for in the Specification and Drawings.

The MCCB shall be so designed that when on tripped condition, the circuit breakers cannot be switched on again unless it has been reset by switching to OFF position first. The operation conditions (i.e. ON, OFF or TRIP) of the circuit breaker shall be clearly indicated.

Moulded case circuit breakers shall be Single Pole (SP), Double Pole (DP) or triple Pole (TP) or four pole (4P) type as required. The construction and operation of the circuit breakers shall be such that if a fault occurs, all

the poles of the circuit breakers shall operate simultaneously to isolate and clear the fault efficiently and safely without any possible risk to the operator or to the installation.

Each circuit breaker shall incorporate “trip-free” mechanism to ensure that the breaker cannot be held closed in fault conditions.

The operating mechanism of the circuit breakers shall be hermetically sealed at the factory and all metallic parts associated with the operating mechanism shall be treated against rust and corrosion. The short-circuit breaking capacity of the MCCB’s shall not be less than the maximum prospective short circuit current at the point where the MCCB is installed.

The Contractor shall be responsible for the selection and provision of the correct type of circuit breakers for protection of the types of circuits involved. The Contractor shall also be responsible for ensuring that the fuses where used in connection with MCCB shall co-ordinate with the circuit breakers to give proper protection and discrimination of the electrical system.

Moulded case circuit breakers may be used in locations where the short-circuit

current exceeds the breaker’s established interrupting ratings provided suitable current limiting fuses are incorporated in the circuit breakers. The ratings of the circuit breakers and fuses must be carefully selected to prevent damage to the circuit breaker and to ensure co-ordination and high short-circuit protection required. The Contractor must provide the relevant data for review by the Engineer before the use of integrally fused MCCB’s.

MCCBs of frame size 100 Amp and above shall each be provided with extended operating handle with padlock facility.

3.3 Miniature Circuit Breakers (MCB)

Miniature circuit breakers (MCB) shall incorporate a fixed adjustable time/current tripping characteristic calibrated in compliance to B.S. 3871 Part 1 at ambient temperature of 40-degree Celsius. Other features of MCB shall be as specified elsewhere for MCCB. All MCB protecting out-going circuits shall be the automatic type of the correct rupturing capacity and equipped with appropriate overload and short circuit protection to suit the particular applications. The short circuit breaking capacity of the circuit breakers shall not be less than the maximum prospective fault levels at the points where the circuit responsible for selecting and providing the correct type of circuit breakers for the protection of the different types of circuits.

3.4 Fuses

Fuses where required shall be high rupturing capacity (HRC) cartridge type Cat. 440/AC4 Class “Q” to B.S. 88.

Each cartridge shall incorporate a fuse element of appropriate current rating and fusing factor in order that adequate protection and discrimination is provided to the circuit.

3.5 Contactors

Contactors for lighting control shall be as specified for service contactors elsewhere in this Specification. The contactors shall be of the number of poles and rated current as shown on the Design Drawings.

3.6 Time Switches

Time switches shall be of the quartz stabilized type with 7-day dial to provide facilities as required of time switch control of any selected service.

Each time switch shall comprise of a quartz controlled clock suitable for operation on 240 Volt +/- 10%, 50 Hz AC supply, a nickel cadmium battery charged by the means supply during normal operation to offer approximately 50 hours running reserve in the event of a mains failure, an analogue face and marking arrow for simple setting and reading, captive push in/push out tappets for setting switching on/off period, override switch, terminal block, a transparent, protective cover, etc.

Contacts for switching on/off the loads shall be made of silver suitably rated to take the connected load.

The time switches shall be similar to MK List No. 5807 or equivalent.

3.7 Residual Current Circuit Breakers

Residual current circuit breakers (RCCBs) shall be the current operated type, 2 or 4 poles as shown on the Design Drawings, suitable for operation on 400/230 Volt, 50 Hz AC system and manufactured to comply with relevant British Standard (BS). The residual current circuit breakers shall be the high sensitivity type with tripping current as shown on the Design Drawings and shall be so designed that the tripping action is completely independent of the supply Voltage. The enclosure of the breakers shall be fitted moulded from high quality insulating material. The main current carrying contacts of the breakers shall be fitted with anti-weld tips and the trip coil shall be completely encapsulated. A test button shall be provided at each breaker to enable the operation of the breaker to be checked regularly. The residual current circuit breaker shall be capable of withstanding, without damage, the thermal and mechanical stresses to which it is likely to be subjected in the case of a fault occurring on the load side of the point at which it is installed.

Residual current circuit breakers shall be of the type approved by the Local Authority and evidence of this shall be produced when requested by the Engineer.

3.8 Digital Power Meter

Digital Power Meter shall comply with the following requirements:

A. Power Meter shall come with Backlight LCD display with minimum 6 lines of display resolution.

B. Power Meter shall have measurement accuracy complying with ANSI C12.1-2008, Class 1 +/- 1%.

C. Power Meter shall provide the instantaneous rms values of the following:

i) Active power total and per phase

ii) Apparent power total and per phase

iii) Current

iv) Frequency

v) Power factor total and per phase

vi) Reactive power total and per phase

vii) Voltage

D. Power Meter shall provide the readings for the Active, Apparent and Reactive energy.

E. Power Meter shall have Modbus RTU RS 485 2 wire as the communication port protocol.

F. Power meter shall provide the following data recording:

i) Alarms

ii) Data Logs

iii) Event logs

iv) Min / Max instantaneous values

v) Time stamping

vi) Trending / Forecasting

G. Power meter shall comply with the following environmental characteristic:

i) EN 61010

ii) UL 508

H. Power Meter shall provide the power quality measurements of the following:

i) Harmonic distortion current and Voltage

ii) Individual harmonics current and Voltage

iii) Sag and swell detection

iv) Waveform captures configurable

I. Power Meter shall provide the demand values of the following:

i) Active power present and maximum

ii) Apparent power present and maximum

iii) Current present and maximum

iv) Reactive power present and maximum.

v) Synchronization for the measurement window

3.9 Technical Specification for Digital Power Quality Analyzer

3.9.1 General

1) The Digital Power Quality Analyzer shall be equipped with 4 Voltage and current measurement inputs. It shall acquire the rms Voltages and currents in power grids from 40 to 70 Hz. By sampling and analog to digital conversion the internal DSP (digital signal processor) determines the electrical quantities.

2) The measured values and the recorded data shall be available for reading out via Ethernet by the software provided. The software provided shall comply with DIN EN 50160 and EN 61000-2-4.

3) Measured values and recorded data can be read out via TCP / IP (Ethernet).

Software shall be provided for configuration and analysis of the recorded data. The fieldbus protocols (Modbus / RTU, Modbus / TCP, Profibus) can be used to control the digital inputs and outputs and to read out current measurement values.

3.9.2 Functional Description

1) Automatic Adaption to power line frequencies from 15 Hz to 440 Hz.

2) Measurement window of 10 (50 Hz) or 12 (60 Hz) periods (200ms)

3) Gapless sampling and calculation of:

a) RMS Voltage line-neutral

b) Star point and unbalance L1…L3 c) RMS Voltage line – line

d) Frequency (same for all inputs)

e) RMS current each input, sum L1 to L3, sum L1 to L3 + N

f) Power active, reactive, apparent, power factor, distortion power)

g) Sum Power L1 to L3 of the above values

h) Active energy (consumed / delivered), main and auxiliary input

i) Reactive energy (inductive / capacitive), main and auxiliary input

j) Voltage and current harmonics (up to 50th order), up to 3.5 kHz) Inter - harmonics, current and Voltage (up to 50th order)

l) Voltage and current THD (total harmonic distortion)

m) Ripple Control signal level

3.9.3 Technical Data

1) Installation Category: CAT III

2) Operating Temperature: -10 °C to +55 °C

3) Storage Temperature: -20 °C to +60 °C

4) Power Supply: 95 – 265 VAC; 100 – 370 VDC, 15 VA

5) Current range: 5A; 0.2 VA

6) Minimum working current: 5 mA

7) Protection Class Front: IP 50 according to IEC 60529

8) Sampling Rate: 28.8 kHz

3.9.4 Interfaces

1) Profibus DP V0

2) RS 485 (Modbus/RTU)

3) Gateway Ethernet to Modbus

4) Fast Ethernet 10/100 Base –TX

3.9.5 Protocols

1) HTTP

2) NTP

3) Modbus TCP & Modbus over TCP

4) DHCP

3.9.6 Acquisition and recording

1) Acquisition and recording of minimum, maximum and mean value of any measurement value, programmable time base.

2) Acquisition and statistical recording (histogram) of a programmable time base.

3) Detection of Voltage sags and swells of at least half cycle duration (only at frequencies 15-70 Hz).

4) Detection of Voltage interruptions.

5) Detection of inrush currents of at least half cycle duration (only at frequencies 15-70 Hz).

6) Detection of transient events from 70 µs.

7) Energy metering (active and reactive, consumed and delivered), 4 Tariffs.

8) Data storage in internal 128 MB flash memory.

9) Line writer for 512 half cycles (rms-values) in case of events.

3.9.7 Digital In / Out

1) 8 digital inputs, used for selection of Tariff, external synchronization and enabling of recordings, pulse counter for external meters.

2) 5 digital outputs, user configurable as pulse or alarm output.

3) 8 programmable comparators for monitoring of up to 4 values each.

3.9.8 Measurement Uncertainties

Value	Frequency Range	Uncertainty	
Voltage	15 – 70 Hz	± (0.2% rdg + 0.02% rng)	
Current	40 – 70 Hz	± (0.2% rdg + 0.05% rng)	
Power	40 – 70 Hz	± (0.2% rdg + 0.0075% rng)	Power factor > 0.8

3.10 Incoming Isolating Switches

Isolating switches where called for at the incoming of distribution boards shall be of the MCCB styled similar to Crabtree 82 Series, MK 5500 Series or equivalent manufactured to BS 5419 (Category AC22).

4. Diesel Generator

4.1 Quality

(i) Inspection

Give sufficient notice so that inspections may be made of a complete set and associated systems at the manufacturers or suppliers factory before delivery to site.

(i) Submissions

a) Product Data

Submit product data for test, manual and auto modes, including the following:

- Technical description and specifications of each generating set, including output curves for prime-rated conditions, alternator and engine data, automatic Voltage regulator, synchronizing and load sharing modules and auxiliaries
- Type test reports for the tests listed
- Net prime-rated output
- Voltage regulation grade
- Generating set efficiency at 50%, 75% and 100% load
- Calculations that the set will start at the lowest temperature and operate at the maximum temperature
- Calculations for the performance of acoustic enclosures and silencers
- Evidence that the engine type has previously passed cold starting tests at the minimum ambient site temperature.

b) Shop Drawings

Submit shop drawings indicating the following:

- Maximum mass and overall dimensions of the package set
- Access clearances for operational maintenance and dismantling
- Control diagrams
- Alarms and shutdown annunciator text engraving schedule
- Details of mounts required
- Details of the weatherproof and acoustic enclosure

c) Test Results

Printed in Operations and Maintenance Manuals.

4.2 Internal Combustion Engine

(i) General

- Cycle: 4 strokes
- Speed: 1500 rpm maximum

- Cooling: Water
- Fuel: Diesel

(ii) Governor

- Electronic, self-lubricating (actuator) suitable for automatic operation with a digital control system.
- Overspeed Control: Electronic.
- Filtered to prevent harmonics and switching spikes interfering with governor operation, under-speed and Overspeed cut-out devices.

Provide adjustments for:

- Speed droop
- Stability
- Maximum speed
- Acceleration rate & Load gain within the engine capacity, minimum ±50%

(iii) Protection

DC operation including:

- Overspeed
- High jacket water temperature
- The low engine water level
- Low lubricating oil pressure
- Crankcase high oil pressure
- Very low fuel in the day tank

“Failsafe”; such that a fault results in the solenoid preventing fuel entering the engine require the system be reset manually at the control panel.

(iv) Starting

Automatic by 12VDC or 24VDC return starter motor plus engine mounted generator/rectifier for starting battery boost.

(v) Fuel System

Capable of the lift required from the base/day tank to the engine fuel inlet.

(vi) Filters

Include:

- Dry-type air-cleaner
- Lubricating oil
- Diesel fuel

(vii) Jacket Heater

Sufficient to keep the engine at a high enough temperature so that it can accept load within 10 seconds.

(viii) Instruments

Engine mounted including:

- Tachometer
- Service hour recorder
- Oil temperature
- Coolant temperature
- Oil pressure
- Manual override starter button
- Engine low-level water alarm
- Engine shutdown emergency pushbutton
- Fail to start and alarm

4.3 Alternator

(i) General

- Type: Synchronous
- Winding Configuration: Star
- Temperature Class: F
- Stator Winding Pitch: 2/3
- Short Circuit Capacity: 250% for 5 seconds minimum
- Enclosure: IP23 standard
- Total Harmonic Distortion at rated load: 5% with resistive load.
- Tropic Proof Windings
- Class H windings are typical for standby applications, for sets that must operate continuously use a higher class (B/E) that have more stringent requirements for temperature rise.
- Stator Pitch of 2/3 gets rid of third harmonics, for other high harmonic loads, specifies pitch to suit. 2/3 also has low zero-sequence reactance so P-N fault currents are high – should easily trip circuit breakers.

(ii) Automatic Voltage Regulator

- Solid State
- Remain within ±1% of set value over 46-54Hz Frequency range steady state
- RMS Sensing on all phases
- The regulated Voltage shall be taken as the average of the phase to neutral of the 3 phases excluding cases where the current ratio is greater than 2:1 between any 2 phases.
- Built-in overload protection
- Adjustable to ±10%, adjusted to generate correct Voltage at output switchboard.
- Include Voltage transient protection

- The voltage shall be re-established within 2 seconds of removing short circuit or restarting the machine.
- On start up under automatic Voltage control and with a resistive load of 30% rated capacity applied the set output Voltage shall be achieved within 3 seconds of the unit reaching a shaft speed corresponding to 46Hz.

(iii) Excitation

- Type: Brushless Permanent magnet exciter
- Torque matching characteristic
- Voltage transient protection for rotating diodes
- Failure of a single diode shall not prevent machine operation

(iv) Overspeed Withstand

1.2x unit rated speed for both engine and alternator

(v) Under speed Withstand

Normal operation at the net continuous rated output at a speed of 90% rated, without overheating.

(vi) Sustained Short-Circuit Withstand

- Maintain at least 300% rated current for 10s to allow operation of protection relays
- Output shall collapse on a short circuit in a manner that does not prevent operation of protection relays
- If electronic trip units are used then collapse during short circuit should not be a problem, the generator circuit breaker is supposed to protect the alternator in any case and should trip if the fault is sustained too long.

(vii) Winding Thermistors

- General: Provide separate thermistors to alternator stator windings for alarms and engine shutdown functions.
- Thermistor type: Positive temperature coefficient.

(viii) Thermistor temperatures:

- Engine shutdown: To suit engine maximum operating temperature and provide warning
- Winding temperature high pre-alarm: To suit winding insulation class and provide warning

(ix) Circuit Breaker

Include suitable Moulded Case or Air Circuit Breaker for alternator protection.

(x) Terminal Boxes

- Construction: Provide metal terminal boxes. Size to allow the current transformers, power and control cables and cable lugs to be neatly installed and terminated with necessary clearances between live parts and the box, and without placing undue strain on termination points.
- Supply cable terminal box: Provide removable lid, side covers and cable gland plates.
- Terminals: Provide star-connected windings. Bring both ends of each winding out to separate terminals. Establish a neutral terminal.

- Sealing: Provide neoprene or bonded cork gaskets between terminal boxes and their frames and covers.

(ix) Anti-Condensation Heaters

- General: Provide anti-condensation heaters within the winding enclosure.
- Rating: Rate heaters to maintain the windings and insulation above the dew point when the alternator is at rest and one heater is in service.
- Location: Locate at least 1 heater at each end of alternator windings in a position which allows heat transfer to the winding insulation by convection, without exceeding maximum allowable insulation temperature. Do not fix heaters to windings.
- Terminations: Connect heaters to separate identified terminals within a separate accessories terminal box which is connected to a permanent supply.
- Connection diagram: Provide a connection diagram for the heaters. Locate within the terminal box.

4.4 Operation

(i) General

Provide automatic and manual modes to start and shut down generating sets in the selected sequence and, if operating in parallel, share the load in proportion to their rated kW and kVAR capacities.

(ii) Automatic Start Control

Provide for the following:

Upon receipt of a "start" signal, for generating set to start automatically, come on-line and connect to the load.

(iii) Automatic Engine Shutdown

Provide for generating set to run to suit the load demand until receipt of the mains "restored" signal. At this point, the automatic sequenced engine shut-down signal must be activated after an adjustable time delay of 0 - 30 min.

(iv) Engine Shutdown

Provide a shutdown control system which disconnects the alternators, and shuts down engines upon the occurrence of fault conditions, such that:

- The engine cannot be restarted before safety devices have been manually reset and system alarm sensors have returned to the normal state.
- The Overspeed shutdown acts directly to disconnect the fuel supply independent of the governor.
- The shutdown control system may be reset by the operation of one reset switch after safety devices have been manually reset.

(v) Emergency and Fault Shutdown

Provide for the following conditions to register as audible and visible alarms and to cause each generating set main circuit breaker to open immediately and generating set to immediately shutdown:

- Emergency stop push-button: Pressed
- Generating set: Over Voltage
- Generating set protection: Activated
- Generating set: Overcurrent
- Engine: Overspeed
- Engine oil pressure: Low
- Jacket water temperature: High
- Day fuel tank: Critical low

(vi) Automatic Synchronizing

Provide synchronizing modules which automatically synchronize each incoming alternator supply frequency and phase angle to the live busbars.

4.5 Control Panels

(i) General

Provide control panels, switchgear and control gear assemblies which accommodate equipment operating in parallel and stabilise load sharing between each generating set at all load steps. Include reverse power interlock.

(ii) Engine Local Control Board

For each generating set, provide the following:

- Key operated local engine start/stop control
- Controls for auto/off/manual
- Emergency manual shutdown
- LCD indication for
  - Speed
  - kVA
  - Power (kW)
  - Reactive Power (kVAR)
  - Voltage, L-L & L-N (V)
  - Current (A)
  - Frequency (Hz)
  - Power factor (average and per phase)
  - Hours run
- Indicators showing generating set under local control or remote control.
- Oil pressure indicator
- Coolant temperature indicator
- Adjustable protection for
  - Undervoltage protection
  - Overvoltage Protection
  - Reverse Power protection
  - Overcurrent Protection
  - Under frequency protection with two stages
  - First stage: Adjustable 47-50 Hz with time delay 0-10 s
  - Second stage: Adjustable down to 40 Hz and with instantaneous trip

  - Low Coolant level
- Day fuel tank low level, indicator and alarm
- Unit running on load, indicator
- Unit running offload, indicator
- Failed to start indicator and alarms
- Anti-condensation heater indicator
- Lamp test button for all lamps
- Volt free contactors for
  - The generator started and ready to accept the load
  - Generator running
  - Common alarm/shutdown
  - Cooldown time complete

4.6 Starting

(i) Electric Starting

General: Provide starter motors, batteries and chargers, and associated control equipment to automatically start each engine.

Wiring: Wire starter motors so that starter motor solenoid contacts are on the active side and field windings are at earth potential when the motor is de-energized. Provide an interlock, connected directly to the engine, to prevent the starter motor operating when the engine is running.

Starting interlock: Provide a starting lockout system, which prevents further starting attempts after 3 (adjustable) successive unsuccessful attempts.

(ii) Batteries and Chargers

a) Starting Batteries

Location: Locate in proprietary battery holders within the package set and constructed of timber or other corrosion-resistant material. Isolate batteries from vibration.

Covers: Provide a high-impact resistant transparent cover for each battery.

Capacity: Sufficient to crank the engine for 6 successive attempted starts, repeated at 10-second intervals.

b) Starting Batteries Chargers

Mains power: Connect chargers to the generating set auxiliary supply so that mains power is maintained when the generator system is in operation.

Alarm outputs: Provide the following local audible and visual alarms together with facilities for extending them via a common alarm output to a remote location:

- Mains off
- Over Voltage
- Overcurrent
- Low battery Voltage
- Insufficient charge rate
- Charger failed
- Battery Voltmeter marked to show the normal range
- Battery charge rate marked to show the normal range
- Battery boost 'ON' status indicator
- Mains 'ON' status indicator

4.7 Installation

(i) General

Mounted in line and direct driven Engine, Alternator and control panel bolted to a common rigid steel base

Coupling: Directly connected to engine flywheel housing.

(ii) Resilient mounts

Prevent the engine base frame from moving on the package floor by resilient mounting blocks between the frame and the plinth.

These shall be to suit the acoustic requirements and seismic requirements

(iii) Coupling

Directly couple the engine and generator shafts using a self-aligning type coupling, capable of transmitting the engine maximum output torque under operating conditions, including starting and overload.

(iv) Signs

Warning: Provide the following on each side of each generating set:

"WARNING: This set may start at any time without notice." Lettering: 50 mm high, red on white background.

(v) Emergency stop push-buttons

Generating sets < 2 m long: Provide one push-button per generating set.

Other generating sets: Provide 2 push-buttons per generating set. Locate one on each side or locate one of the push-buttons in the engine local control board.

Type: 40 mm diameter red, palm operated latched mechanical type mounted in a metal wall box fixed to a free-standing "U" channel pedestal. Wire to disconnect the generator and immediately shut down the engine when the controls are in the automatic or manual mode.

(vi) Fuel connections

Stop valves: Provide stop valves on the inlet to, and outlets from, the daily service tank.

(vii) Safety Guards

Provide safety guards to prevent contact with any rotating or high-temperature parts, at least complying with the relevant Occupational Health and Safety Authority.

4.8 Sound proofing

(i) General

Provide sound proofing to the generator room including inlet and outlet sound attenuators.

(ii) Sound Pressure Level Limit

65 dB(A) daytime at 1 m from the exterior wall surface, at 1.5 m above floor or roof levels, measured with the generating set operating at constant maximum rated full load output, with doors closed and service penetrations sealed.

(iii) Doors

Provide soundproof type doors with heavy-duty door lock.

(iv) Fresh air and Hot air attenuators

Provide attenuators to the generators so that:

- With generating sets running at the full rated output the enclosure temperature-rise does not exceed manufacturer limits.
- With proper dimension to achieve sound level stated above
- Hazardous concentrations of toxic or explosive fumes and gases are prevented.

(v) Room treatment

Double wall with cavity shall be provided as per the manufactures recommendation to achieve the required sound level. Supplier shall provide proper detail to the Civil Contractor.

Where double wall with cavity is not applicable glass wool cladding shall be installed.

Acoustic ceiling shall be done using spring hangers to the slab.

(vi) Other considerations

Consideration shall be given for sound proofing where pipe, cable penetrations and trenches which passing through the walls.

4.9 Engine Air Intake

(i) General

Provide dry type air intake filters of sufficient capacity to permit continuous engine operation for 200 hours before filter servicing becomes necessary.

4.10 Exhaust System

(i) General

General: Provide exhaust piping from the engine complete with silencers, piping, ductwork, supports and expansion devices.

Exhaust piping: Grade 304 Stainless steel.

Diameter: Match engine exhaust manifold connection.

Connections: Provide stainless steel flanged connections to silencers and pipe interconnections.

Vibration isolation: Provide a stainless-steel flexible connection to the engine.

(ii) Weatherproofing

Provide weatherproof flashing, sleeves and acoustic seals where the exhaust system penetrates the roof or external walls.

(iii) Exhaust Drainage

Grade the exhaust line away from the engine to drainage pockets, or connect to a suitable drainage outlet.

(iv) Lagging

General: Lag internal exhaust piping and ductwork using calcium silicate insulation sheathed using zinc-coated steel sheet.

Lagging thickness: to achieve a touch temperature of maximum 50°C, maximum, 55 mm (minimum)

(v) Silencer

Type: Absorption/reactive

Backpressure: Not to exceed engine manufacturer limits

Construction: 304-grade stainless steel outer housing, the internal steelwork and reactive chambers shall be stainless steel or HRCQ mild steel. Absorption material shall be covered with a 304-grade stainless steel perforated sheet.

4.11 Marking

(i) Rating Plates

Temperature-rise limits: If temperature-rise limits are achieved by de-rating an oversized generator, state the de-rated value.

Alternator mass: State alternator mass.

(ii) Thermistor Detector Identification and Warning Plates

Thermistors: Provide details of thermistor type classification and the reference temperature.

Warning: Provide a warning engraved in 4 mm high lettering as follows:

- "WARNING - Do not apply more than 2.5 V across the protection thermistor devices"

Anti-condensation heater identification and warning: Locate next to heater terminals. State the number, Voltage and power rating of the heaters, and the following separate warning engraved in red letters on a white background:

- "WARNING - Anti-condensation heater. The circuit is live when the set is off"

(iii) Auxiliary Wiring

Provide ferrules to wiring ends identifying each conductor.

(iv) Engine Direction of Rotation

General: If driving shafts or associated rotating parts are accessible, clearly and permanently mark the direction of rotation on an adjacent fixed surface.

Rotation identification: Provide a label within the supply cable terminal box identifying the relationship between the direction of rotation and the marking of terminals.

(v) Charger Enclosure Markings

General: Provide enclosure with:

- Main nameplate engraved in 10 mm high lettering
- Minor nameplates engraved in 4 mm high lettering to the interior and exterior components
- Manufacturer's rating plates
- Plate material: Stainless steel.

(vi) Enclosure Signage

Fit the following signs to doors:

- "Wear hearing conservation protection"
- "WARNING: This machine may start at any time without notice", in red lettering on white background

4.12 Completion

(i) Testing

Acceptance Tests Generally

General: For each generating set carry out the following:

- Check the tightness of connections and securing devices.
- Verify correctness of operation of protection devices and systems including sensor settings. Simulate actual conditions as far as possible, in order to test responses to faults imposed.
- Provide fan-cooled resistive test load tank if not installed permanently.
- Cold start with the engine having been at rest for the previous 24 hours, timed from receipt of mains failure signal to acceptance of full rated load in 3 load steps to within the limits of output Voltage and frequency. Record Voltage waveforms. Jacket water heaters are to be operational.
- Continuous operational trial consisting of:
  - 4 hours at 100% rated power
  - 1 hour at 110% rated power
  - 1 hour at 100% rated power
  - 30 min at 75% rated power
  - 30 min at 50% rated power.
  - Record fuel consumption for each step of the continuous trial
  - During testing measure ambient temperature and coolant temperature and submit a calculated performance for maximum ambient conditions
- Sample engine oil from engine sump before and after tests
- Perform laboratory analysis and submit a report on each oil sample
- Continuous operational trial: During the trial, measure the following at maximum intervals of 30 minutes:
- Generator kW and kVAR output
- Generator output Voltage
- Generator output current
- Generator output frequency
- Power factor
- Oil pressure and water temperature
- Electrical power requirements of continuously running electric motor driven ancillaries
- Each battery charger current and Voltage readings
- Noise level

Acoustic Performance

At the completion of the installation carry out thorough testing to demonstrate compliance with the above requirements. Submit for approval noise test results from a recognised testing authority.

Temporary Test Loads

Provide test loads (load bank) including power and control wiring, ancillary equipment and test instruments to achieve the kW and necessary load steps.

Final Tests

Submit reports from manufacturers or suppliers verifying the performance of safety and control functions of each system.

Charging

Fill tanks with fuel, and top-up immediately before practical completion after generator testing.

(ii) Maintenance

Call out
Respond to call-outs for breakdowns or other faults requiring corrective maintenance within 2 hours. Attend on-site if required to rectify faults and replace faulty materials and equipment.

4.13 Diesel Generator – Liquid Fuel System

Base tank with 1 day (8 hours @ Full Load per day) fuel storage is proposed. Approx. 1000L of total storage. Day tank with the mentioned 1000L storage is also accepted, given that the contractor confirms the adequacy of space in the nominated Generator room. Bulk tank is not required.

4.13.1 Quality

(i) Contractor's Submissions

Valves

Valve Schedule: Submit a detailed schedule of valve types showing manufacturer, figure number, materials, pressure rating and application.

Fuel Level Indicators

Submit details of ultrasonic level indicators

(ii) Pre-completion Tests

Site Tests

Discharge and suction piping: Pressure test to 350kPa. During tests keep tanks freely vented so that they are not subjected to the test pressure.

Fill, dip and vent lines: Air pressure test to 35 kPa. Fit a safety device to ensure that this pressure is not exceeded and remove the device after the test is completed.

On completion of testing: Remove water and other contaminants from tanks, valves and pipe fittings. If necessary, lubricate valve seats and poppets and seal inspection plugs with black pipe jointing.

Preparation for Testing

- Isolate items of equipment and instruments not designed to withstand test pressures
- Use spades or plugs for isolation rather than valves
- Secure pipes and fittings in position to prevent movement during tests
- Restrain expansion bellows
- Leave pipe joints exposed to enable observation during testing
- Fill piping prior to testing and allow it to come to room temperature and for condensation to evaporate.

Test Material

Piping type	Test material
Fuel oil piping	dry nitrogen or dry air

Test pressures: Test systems at 1.5 x working pressure of 1 MPa, whichever is the greater, held for 8 hours.

Test criteria: No leaks or loss of pressure over the test period after taking account of any change in ambient temperature.

(iii) Inspections

Witness Points

Give notices of inspection at the following hold points:

- Hydrostatic testing: At the commencement of each pressure test and prior to the release of test pressure for each section to be tested, all to be conducted prior painting or insulation
- Inspection of underground tanks and associated fittings and pipework prior to backfilling
- Flushing and pre-treatment of pipework prior to final filling up

4.13.2 Daily Service Tank (If provided)

Construction

Open: Welded construction, reinforced around the top edge. Provide a lid fabricated from zinc-coated steel 4mm thick with a rolled edge.

Closed: Welded construction. Provide a bolted inspection cover. Single-walled.

Tank Stands

Provide a welded frame stand at least 900 mm high, fabricated from mild steel angle.

Tank Connections

Drain connection: DN 25 boss and screwed plug.

Flow connection: ≥ DN 20

Supply connection: ≥ DN 25

Overflow return connection: Sufficient to allow 125% of pump capacity to be returned to the main tank without overspill.

Vent connection for closed tanks: ≥ DN 40

Controls

Provide liquid level switches set to start the liquid transfer pump at low liquid level (half full), and cut the pump out at a high level (full).

Provide liquid level switches to shut down the engine at 10 minutes of fuel left.

Provide overflow alarms.

Auxiliary Contacts

Provide Voltage-free contacts set to close on a fall in the liquid level to one-third full.

Indication

Provide a fuel level indicator with calibration in litres.

4.13.3 Finishes

External

General: Blast clean steel tanks and associated steelwork, including hold-down bolts and straps, to class 2, and apply coating systems within 4 hours of blast cleaning.

Tank Finishes Table

Tank type	Coating system
Underground tank	Tar free high build polyamide cured epoxy. Minimum coating thickness: 200 mm.
Above ground tank	Inorganic zinc silicate to GPC-C-29/8, followed by polyurethane to GPC-C-29/11
Tank enclosed in chamber	Inorganic zinc silicate to GPC-C-29/8
Service tank	Inorganic zinc silicate to GPC-C-29/8

Internal

Remove debris and clean.

4.13.4 Piping and Accessories

Pipes Inside Tank

Heavy steel pipe.

Filling and Service Piping

General: Medium steel pipe.

Filling: ≥ DN 75.

Service: ≥ DN 25.

Joints for Steel Piping

Welded.

Cleaning

Flush out piping with fuel, only when the system is complete.

Underground Piping

Provide double-skinned pipes.

Temporarily support the piping in the trench before backfilling. Provide at least 150 mm of backfilling all around piping. Comply with Sand backfilling in Underground tank installation.

Gradients

Lay piping to permit self-draining and avoid air locking, and to the following minimum gradients:

- Fill pipe: 1:50 down in the direction of flow
- Gravity return pipe: 1:100 down in the direction of flow

Corrosion Protection

Wrap steel pipe and screwed or welded joints with anti-corrosive grease impregnated tape or other purpose-made vapour barriers adhesive plastic tape. Extend the tape 150 mm from the extremity of any thread or weld.

Lock Boxes

General: Provide 300 mm diameter cast iron boxes with lockable cast iron cover flaps, to each filling and dip point and buried valves.

Installation: Set boxes with the top 25 mm above the adjacent finished pavement or ground surface. Surround and support the box with concrete, at least 150 mm thick. Provide gravel underlay to drain the box.

4.13.5 Design

Design piping and supports to accommodate fluid pressures, the weight of full piping, seismic loading, thermal expansion, building movement and plant vibration.

Performance

Design Pressure

- Not less than the maximum hydrostatic head at the location plus the pump shut off the heat at the maximum impeller size

Hydrostatic test pressure: 1.5 times design pressure of 1 MPa, whichever is the greater measured at the lowest point of the system.

Piping Installation

General

General: Install piping in straight lines at uniform grades. Arrange to prevent air locks or liquid trapping. Provide sufficient unions, flanges and isolating valves to allow removal of piping and fittings for maintenance or replacement of plant.

Layout: Run piping parallel or at right angles to adjacent building elements. Coordinate to clear other services.

Arrangement: Arrange and support piping so that it remains free from vibrations whilst permitting necessary movements. Minimise the number of joints and fittings.

Spacing: Provide at least 50 mm clear between pipes and between pipes and building elements.

Concealment: Conceal piping in occupied areas where possible.

Cleaning

General: Before installation, clean piping and remove loose scale, burrs, fins and obstructions.

Protection: During construction, prevent the entry of foreign matter into the piping system by temporarily sealing the open ends of pipes and valves using purpose-made covers of pressed steel or rigid plastic

4.13.6 Supports

Support piping without sag, with falls for complete venting and drainage, with flexibility for expansion, contraction and vibration isolation. Provide clamps, hangers, spreader beams, trapeze hangers, secondary steelwork, guides, pipe anchors, expansion devices, brackets, fixings and the like.

Arrange supports to prevent pipes from transferring stress to connected equipment.

Provide independent supports for metallic valves and fittings in non-metallic pipelines.

Support for Multiple Pipes

Horizontal pipes: Use trapeze hangers, support brackets or pedestals.

Vertical pipes: Anchor risers not subject to expansion to galvanised steel channels at all floors. Anchor expanding risers centrally or at the base and provide guides at all floor levels

Support Spacing

Metallic pipe: As tabulated.

4.13.7 Vibration Isolation

General

Minimise the transmission of vibration and noise from equipment through piping to the building structure and occupied areas.

Support of Piping at Pumps

Ensure that piping does not impose loads on equipment connections.

Extend pump floating bases to accommodate supports for pump suction and discharge elbows.

4.13.8 Valves and Accessories

(i) General

Function

Provide all valves, fittings and accessories necessary for operation, control and maintenance of the systems.

Components

Valve size: Generally, the nominal pipe size, unless a smaller size is necessary for throttling purposes or flow measurement.

Connections

Handwheels and handles: Removable, with the direction of closing marked permanently on handwheels. Drain cocks and vents may have a diamond head.

Valve closure: Clockwise unless required otherwise by statutory authority.

Flow direction markings: Cast arrows on valve bodies.

(ii) Materials

Galvanic Compatibility

Select materials for valves and fittings which are less susceptible to corrosion than adjacent piping.

(iii) Selection

Pressure rating: Minimum 1.4 MPa, and to suit system pressure requirements.

Temperature rating: To suit system requirements.

Limitations on size and type:

- Isolating valves:
  - Gate valves: No limitation
  - Ball valves: ≤DN 50
- Throttling valves:
  - Globe valve: No limitation

Gate Valves

Description: Straight-through flow, solid wedge type, inside screw design, medium pattern.

Ball Valves

Description: Full bore pattern with the handle parallel to the direction of flow when the valve is fully open.

Non-return Valves

Swing type

- Water supply - metallic gate, globe and non-return valves
- Body: Bronze alloy or cast iron, Cast iron non-return valves for general purposes
- Plates: Bronze alloy or stainless steel

Dual flap type

- Body: Cast iron
- Pin and spring: Stainless steel
- Seat: Integral nitrile rubber
- Plates: Bronze alloy or stainless steel

Pressure Relief Valves

Description: Direct-acting, spring-loaded with adjustable setting.

Standard: Safety valves, other valves, liquid level gauges and other fittings for boilers and unfired pressure vessels.

4.13.9 Fuel Oil Pumps

Size

Sufficient to ensure that the duty pump can refill the daily service tank at not less than four times the rate of full load consumption of the engine.

Configuration

Duplex in duty/standby configuration for each engine.

Type

Self-priming positive displacement internal gear type pumps with mechanical seal and direct driven by a totally enclosed motor.

Bypass

Provide an automatic built-in overpressure bypass with adjustable spring relief.

Mounting

Mount the motor and pump on a common base plate.

Material

Casing and rotor: Cast iron or cast steel.

Shaft: Hardened steel.

Drip Tray

General: Provide a 50 mm deep drip tray under each pump.

Material: 1.6 mm thick copper with brazed joints.

Control

Method: PLC within dedicated pump control panel, Tank level sensors and line pressure/flow switches.

Operation of the fuel transfer pumps shall be as follows:

- Duty pump shall operate to fill the day tank from the bulk tank in the event of a low day tank signal.
- Duty pump shall stop filling the day tank in the event of a high day tank signal.
- Standby pump shall operate in the above fashion in the event of duty pump failure, whether the failure occurs with duty pumps in manual or auto mode.
- Designation of duty/standby pumps shall be alternated at each start call on the local generator control panel to average out pump debilitation.
- Fuel pumps shall be provided with a means of manual operation from adjacent the respective set of service tank(s)

Each Control Panel shall:

- Contain all the control equipment for the pumps and valves, including the automatic control modules to suit the mode of operation described, including all interfacing equipment, apparatus and circuit protection devices
- Comprise, but not necessarily be limited to the equipment and functions described in this specification and associated drawings, required to fulfil the intent of the specification
- Incorporate an audible alarm and mute switch for notification of any faults in conjunction with the fault indicators
- Contain terminal strips for all interface wiring to the BMS and generator control panels

Wiring

External Type: MIMS

Internal to Control panel: V75

4.13.10 Installation

(i) Underground Tanks

Excavation and Backfilling

Keep excavations free of surface water. After placing the tank, backfill with sand or pea gravel as recommended by the tank manufacturer

Sand Backfilling

General: Use chemically inert sand or pea gravel, free from foreign matter such as salt, organic matter and clay lumps, and graded.

Placing: Place sand backfilling in layers not more than 200 mm thick, and compact to a minimum density index of 75%.

Sand grading table

Sieve aperture (mm)	Percentage passing (by mass)
9.5	100
4.75	70 - 100
2.36	50 - 100
0.425	15 - 70
0.075	0

Ballasting

If ballasting is necessary to prevent flotation, fill the tank with water before backfilling.

EITHER

Provide a concrete ballast collar at least equal to the weight of the full tank.

OR

Provide deadman weights and certified tie-down tackle as per tank manufacturer's recommendations.

(ii) Trench Covers

General

Provide covers for fuel pipe trenches in concrete floors.

Cover Material

6 mm thick mild steel chequer plate, cut to fit floor trench rebates, galvanized after fabrication.

(iii) Cathodic Protection

System

General: Provide a cathodic protection system for underground steel tanks, using either a sacrificial anode or an impressed current, designed and installed by a suitably qualified person.

Characteristics: Provide the following:

- Monolithic insulating couplings in the suction, vent return and fill lines immediately next to the tank

- Power supply, anodes and interconnecting wiring, incorporating a facility for periodic testing

- Insulation to the return connection

Power supply: Provide solid state regulated DC power supply with balanced outputs and ammeter.

(iv) Contents Indicators

Dipsticks

Form from brass section or anodized aluminium extrusion, with the bottom 100 mm coated with nylon or equivalent non-conducting coating. Stamp or engrave calibrations at intervals of not more than 5% of nominal tank capacity.

Contents Gauges

Provide a remote-reading contents gauge. If the vent pipe is not visible to the filling operator, locate an additional gauge next to the filling point.

4.13.11 Marking

Identification of the contents of pipes, conduits and ducts.

Method: Apply self-adhesive pipe markers with colour identification blocks and flow chevrons to prepared surfaces. Remove redundant flow chevrons.

Wording: Identify pipe contents using complete words matching contract drawings. Include “FLOW” or “RETURN” for recirculating systems.

Display piping hazard identification where applicable.

4.13.12 Completion

(i) Charging

General

Fill tanks with fuel, and top-up immediately before practical completion after generator testing.

5. Lighting and Power Installation

5.1 General

The Design Drawings for the lighting and power service installation indicate approximate positions of all luminaires, switches, switched socket outlets and other outlets/points, etc. but the actual positions of all fittings including the wiring layout and cable routes shall be agreed finally on site with the Engineer having due regard to the selection of the most accessible routes for wiring and the convenience of switching.

5.2 Luminaires

5.2.1 General

The types of luminaires to be provided are shown on the Design Drawings.

Other types of luminaires without designation but shown only as lighting points are covered under a Provisional Sum. However, the Contractor shall be responsible for taking delivery on site, checking on the consignments for defective items including arrangement for replacements by suppliers, storage at site, fixing of lamps, installation and site testing of all these luminaires covered under the Provisional Sum including replacements of lamps/tubes and defective parts/fittings during the Maintenance Period. The Contractor shall also be responsible to provide all necessary fixing accessories, mounting brackets, supports, r.c. stumps/bases, heat resistant flexible cords, etc. as required to install all the luminaires covered under the Provisional Sum. All costs connected therewith shall be deemed to have been included in the Contract Sum.

All luminaires shall be manufactured to the strictest tolerances where practicable.

Ventilation slots shall be provided on the casing of luminaires, where required.

All luminaires shall be designed for operating on 230V +/- 6%, single phase, 50 Hz AC supply.

All luminaires used as emergency luminaires including exit signs shall be constructed and installed in accordance with the local authority requirement.

Fittings and accessories for external use shall be of weatherproof construction specially treated against corrosion for use in salt laden atmosphere. Totally enclosed luminaires shall have sealing gaskets and shall be insect-proof.

Cables used for internal wiring of the luminaires shall be of appropriate type and size and shall not be less than 0.5mm^2 in cross-sectional area. The insulation of the cables shall be able to withstand throughout the life of the luminaires the maximum temperature of not less than 105 degree C to which it will be subjected in normal use without deterioration which could affect the safety of the luminaires.

Cables within the luminaires shall be neatly bundled by nylon self-locking cable ties. Wiring shall be properly routed and secured from heat-generating accessories like control gear etc. wherever possible.

All cable terminations within the luminaires shall be suitably shrouded.

At every luminaire an earthing terminal shall be provided for connection to the circuit protective conductor.

5.2.2 Metalwork of Luminaires

Unless otherwise specified elsewhere, ferrous metalwork of all luminaires shall be made of mild steel sheet of minimum thickness 0.8mm. The metalwork shall be derusted by treating with Deoxidize 125 or Deoxidize M and degreased by Trichloroethylene or wiping with clean cloth dipped in thinner. The metalwork shall then

be dipped in Kephas before phosphatizing. After drying, the metalwork shall be sprayed with two coats of alkyd-based enamel paints and then stove in a baking oven to the specified temperature of the paint manufacturer and for the recommended time. The total thickness of the two coats of paints shall not be less than 50 microns. When the basic sheet steel is electro-zinc plated (zincron), the total thickness of the two coats of paints can be 25 microns. The thickness of the paint will be measured in random samples during supply to check conformity when required by the Engineer.

5.2.3 Diffusers and Reflectors

Plastic diffusers where used, shall be of non-deteriorating, and ultra-violet stabilized material, and shall not change in shape with time or due to handling. Plastic diffusers shall be washed with a detergent solution and dripped-dry immediately prior to installation to restrict electrostatic dust adhesion.

Louvred mirror reflectors of the fluorescent luminaires where called for shall be die-formed semi-specular anodized aluminium in parabolic form to give good light distribution and efficacy. Metal louvres where called for shall be of a design to give a 'bat-wing' light distribution with a downward light output ratio of at least 70%. The lamps will be screened from view along both directions of the lamp axis by metal louvres. The entire metal louvre should be able to hinge down from one side of the luminaires for maintenance purposes and snap fit back into position.

5.2.4 Installation Requirements – Non-Essential Luminaires

Each lighting point in areas having false ceilings shall be terminated with a B.S. ceiling rose in the soffit of the slab.

Each lighting point in areas without false ceilings shall be terminated at a concealed B.S. circular conduit box having entries appropriate to the run of conduit. At each lighting point the wiring shall have an excess length of about 150mm before terminating to a connector. The circuit protective conductor shall also be wired to the connector.

Each surface mounted luminaire shall be terminated at a B.S. junction box having entries appropriate to the run of conduit and shall be complete with connectors and suitable for the size and number of connections to be made at the point and the wiring required to connect the specified luminaires. Wiring to luminaires within the false ceiling space shall be carried out by means of heat resistant (butyl or silicon rubber insulated to B.S. 6500) flexible cables with copper conductor of cross-sectional area not less than 1.5 sq. mm to be connected from a B.S. ceiling rose to the lighting fitting.

Recessed luminaires shall be suitable for housing in concealed or exposed (T bar) ceiling modules where appropriate. All recessed luminaires shall be supported from the r.c. ceiling slabs using appropriate fixing accessories such as steel rod, spring clips, ceiling brackets, suspension hooks, profile brackets, etc. to ensure proper installation of the luminaires on different types of ceiling panels. In areas where luminaires are installed directly below large ductworks etc., the Contractor shall install suitable brackets, channels, etc. to facilitate suspension/support of the luminaires from the ceiling slabs; all costs connected therewith shall be deemed to have been included in the Contract. An adjustable resilient spring-clip shall be provided to enable the suspension length to be adjusted to fine tolerances. Suspension sets shall be proprietary make of adjustable type designed to carry the weight of the luminaires; the suspension sets shall be of adequate lengths for installation on the false ceiling panels concerned. Suspension rods shall be of at least 5mm diameter and shall be fixed at positions recommended by the luminaires manufacturers.

At least 4 suspension rods shall be provided for each luminaire/luminaires shall be supported in a manner that will ensure that the weight of each luminaire is equally distributed to all supporting rods with the

luminaires remaining in level position. Suspension sets where exposed to sight shall be of adjustable rod type of minimum diameter 20mm with all necessary accessories.

5.2.5 Installation Requirements - Essential/Emergency Luminaires

For luminaires associated with the essential/emergency supply circuits, wiring shall be terminated as follows:

(i) Surface mounted luminaires shall be terminated at a B.S. junction box having entries appropriate to the run of conduit and shall be complete with connectors and suitable for the size & number of connections to be made at the point & the wiring required to connect the specified luminaires.

(ii) For recessed luminaires (i.e. luminaires mounted on suspended ceilings), the wiring from the ceiling rose to the luminaires shall be carried out by means of FR cables.

For luminaires with emergency power packs, an unswitched live wire shall be connected to each and every luminaire with emergency power pack so that the luminaires concerned can be switched off from the associated lighting switches, timers, contactors etc.

For emergency lights installed at high level above 6 meters above finished floor level, central battery system shall be provided.

5.2.6 Installation Requirements - Essential/Emergency Luminaires

For luminaires associated with essential/emergency supply circuits, wiring shall be terminated as follows:

(i) For surface/wall mounted luminaires, cables shall be terminated at a ceramic fuse-carrier mounted within the luminaires.

(ii) For recessed luminaires (i.e. luminaires mounted on suspended ceiling), cables shall be terminated at a ceramic fuse-carrier mounted within a metal-clad terminal box securely fixed to the underside of the structural members within the ceiling space adjacent to the luminaires and the connection from the terminal box to the luminaires shall be by means of fire resistant cables, plug and socket with the socket incorporated in the terminal box enclosure in such a position as to facilitate withdrawal of the plug in the event of collapse of the ceiling.

The supply side of the aforesaid fuse carriers shall be sleeved with high temperature grade insulating material and the rating and characteristics of the fuse-element shall be properly selected to ensure proper protection of the circuit and discrimination with the upstream protection devices.

For luminaires with emergency power packs, as unswitched live wire shall be connected to each and every luminaire with emergency power pack so that the luminaires concerned can be switched off either from the associated lighting switches, timers, contactors etc.

5.2.7 LED luminary

LED sources shall be tested to IESNA recommendations as outlined in LM80-08. Submit evidence of testing prior to ordering.

Lamp construction and installation must be in accordance with manufacturer's standard recommendation.

Maximum LED junction temperature allowable for operating current is as follows:

- 98 ºC for 350mA
- 90 ºC for 500mA
- 81 ºC for 700mA

Note: Junction temperature are to be based on testing of Luminaire, OEM manufacturer data will not be accepted.

LED components (LED chips etc.) are to be from reputable manufactures (i.e. Cree, Luxeon or Nichia).

LED lamp colour stability performance to be within the parameters of the MacAdam index minimum step four (4).

Lumen depreciation factor should be minimum L70.

LED luminaries shall be supplied with OEM details and "binning" data and the CIE chromaticity coordinates. Emergency lighting is excluded from this requirement.

LED lamps shall have a fully stabilised colour temperature over the life of the lamp.

LED lamp modules must be replaceable.

Minimum lamp life 30,000 hours with 10% lamp mortality.

5.3 External Lighting

Lighting poles for external lighting where called for shall be of tubular hot dipped galvanized steel column, the base compartment of which shall house the lamp fuse gear consisting of a single fully shrouded single pole and neutral single entry type cut-out with 5 Amps HRC fuse complete with cable sealing box, armour clamps and compression gland, where required, suitable for reception of looping PVC/SWA/PVC cables or PVC cables of the sizes as required. The tubular columns shall be protected internally and externally against corrosion. For internal protection, a coating of black bituminous paint shall be applied. A priming coat of suitable paint shall be applied to the surface after it has been thoroughly cleaned and followed by at least two finishing coats to provide adequate protection against corrosion. The colour shall be to the Engineer's review.

Wiring between lantern and cut-out shall be twin core 2.5 sq. mm tinned annealed circular copper conductor PVC insulated black PVC sheathed incorporating within the sheath a bare circuit protective conductor of the same cross-sectional area.

An appropriate concrete base shall be provided for each outdoor luminaire for mounting onto the ground.

Each outdoor/external lighting point shall be terminated in a weatherproof polyester junction box of IP 65 similar to Legrand 95950 or equivalent.

5.4 Switches

Sub-circuit switches unless otherwise shown on the Design Drawings shall be single pole, quick make and slow-break, silent switch action type with solid silver alloy contacts and totally enclosed switch action for flush wall mounting or ceiling mounting as required and shall be suitable for indoor or outdoor service according to location, housed in standard purpose manufactured galvanized steel boxes complete with conduit knockouts made up into single or multi-gang units employing a grid switch system of fully interchangeable components as standard fixing centers of matching switches of different types and ratings but of identical dimensions, push buttons, neon indicator lamps, blanking units, grid, steel boxes and plates all capable of integration into standard composite assemblies in any combinations as required.

Grids shall be adjustable for variation in depth of plaster and for squaring errors and of the same type for surface or flush mounting.

Switches in mechanical plantrooms and electrical sub-stations and switch rooms shall be of the metal clad type subject to review by the Engineer, mounted in flush or surface conduit boxes as specified.

Switches for wall mounting in other locations shall be of 'Rocker' type similar to 'MK'- logic Plate switches'. Switches mounted on aluminum door frames shall be similar to 'MK - Logic Architrave plate switches. Switches located on brick or concrete walls shall be mounted in horizontal arrangement in galvanized steel boxes using box suspension straps. Counter-sunk screws shall be provided for fixing to the conduit box. Ceiling switches where used, shall be similar to MK Cat. No. 3190 complete with mounting bases and pull cords.

Switches for external use shall be of weatherproof construction and of standard similar to Walsall make or equivalent.

Samples of all switches, conduit boxes etc. and a schedule showing the type of switches to be installed at all locations shall be submitted to the Engineer for review prior to placing orders.

Switches associated with essential supplies shall be provided with red toggles. Switches shall be rated 5 Amps or 15 Amps as determined by circuit load suitable for use in AC inductive circuits or fluorescent lamp circuits, of the one way or two way type as indicated on the Design Drawings and fixed generally at a height of 1400 mm from the floor level where possible be located on the inside of the room on the handled side of the door as close to the door as practicable.

An earthing terminal shall be provided and connected to circuit protective conductor at every lighting switch position.

Single pole switches shall be connected to break the phase wire of the supply. The neutral wire shall not be routed through switch boxes.

Switches which are mounted in the same position adjacent to each other shall be of multi-gang type of the maximum number of gangs available.

5.5 Switched Socket Outlets

Switched socket outlets shall be to local regulation and BS standards.

Switches shall be of the quick make, slow break type with silent, totally enclosed switch action and solid silver alloy contacts. Switches socket outlets for indoor use shall be housed in suitable galvanized steel boxes to B.S. 4662 with conduit knockouts. Types and finishes of switched socket outlet plates for various areas shall be as specified for the lighting switches.

Switch socket outlets located in exposed situation shall be non-shuttered, single-pole 3 pin to B.S. 546, galvanized iron weatherproof type with 20 mm E.T. screwed conduit entry, rated at 13 Amp switched or unswitched as shown on the Design Drawings complete with protective captive screw-on cap to cover the socket orifice when not in use.

Switched socket outlets shall be positioned as per the ID's requirement.

Switched socket outlets associated with essential supplies shall be provided with red toggles.

Samples of all switched socket outlets and a schedule showing the type of switched socket outlets to be installed at all locations shall be submitted to the ID / Architect for review prior to placing orders.

5.5.1 Ground Fault Circuit Interrupter (GFCI)

Socket outlets with a built-in GFCI shall be provided for bathroom, laundry, exterior and other areas for the ground fault protection.

GFCI shall be Class A, 5mA sensitivity as specified in NEC standards.

5.6 Plugs

Each weatherproof switched socket outlet shall be provided with a weatherproof plug of the same manufacture. The plug shall be housed in an alloy case with clamping ring and screw down compressible gland capable of accommodating a flexible TRS 3 core cable of dimensions appropriate to the current rating of the plug.

5.7 Fused Connection Units

Fused connection units shall be of unswitched type each comprising a fuse carrier fitted with a 5 Amps cartridge fuse-link to BS 1362, an outlet for connection of flexible cord up to 2.5mm^2, 3 core, terminal block, etc. Each connection unit shall have a built-in safety shutter which closes over the live contacts immediately the fuse carrier is withdrawn. The carrier shall be secured firmly in position by a screw but automatically withdraws from the live socket as the screw is released. The connection units shall be of flush wall mounting type and housed in suitable galvanized steel boxes to B.S. 4662 with conduit knockouts. The finishes of fused connection units used at the various areas shall be as specified for the lighting switches

5.8 Isolating Switches

Isolating switches shall be manufactured to BS 5419 (Category AC 22) of the number of poles and current ratings as shown on the Design Drawings and shall be of the totally enclosed pattern, metal-clad or polycarbonate with positive quick-make and quick-break action.

Isolating switches shall generally be mounted at a height of 1400 mm.

Switches shall be capable of withstanding and also interrupting their full rated current safely and without damage. Ferrous materials shall be galvanized, switch handles shall be interlocked to prevent opening the cover with the switch ‘ON’. The covers/doors for metal clad types shall be provided with gaskets.

Isolating switches for use in distribution boards shall be of the MCCB styled similar to Crabtree 82 series, MK 5500 series or equivalent.

5.9 Cooker Control Units

Cooker Control Units shall be flush mounted conforming to BS 3676 having a double pole AC switch rated at 30 Amps complete with pilot indicating lamps and a self-adhesive plastic identification label mounted on removable chassis contained within a steel box finished aluminium stove enamel provided with conduit knockouts and earthing terminals.

5.10 Shaver Outlets

Shaver sockets shall comply with BS 3052 and shall comprise a 20 VA continuously rated double would isolating transformer to provide an earth-free AC supply at mains frequency, complete with self-resetting thermal overload device filled in the primary circuit, an insulated Voltage selector switch to provide either 115 or 230 Volts output, one ON/OFF switch and one universal socket outlet suitable for British, American, Continental and Australian razor plugs, all contained in a recessed sheet steel box with insulated moulded front plate suitable for flush mounting and suitably inscribed to give a clear indication of the Voltages available at the outlet and the service of the outlet.

5.11 Switch Panels

Switch panels shall be the wall mounted type fabricated from sheet steel of at least 18/20 swg as required by the Engineer. The panels shall be of similar construction/finish as the distribution boards, each complete with hinged door, panel mounting switches (flush type) of appropriate current and Voltage ratings, phase barriers, warning signs, neon indicators and label for each switch, circuit diagrams secured as per distribution boards and wiring to the items on the hinged panel shall be so arranged that the panel can be easily opened without straining the cables. Working drawings of the switch panels shall be submitted to the Engineer for review before fabrication.

5.12 Radio Interference Suppression

Certain types of electrical equipment or systems involving sudden changes, or low frequency or of direct electric current such as contactors etc., supplied and installed under this Contract shall be fitted with radio and television interference suppression components suitable to meet the levels specified in B.S. 800.

5.13 Lighting Control Dimmers

Lighting control dimmer where called for shall be the solid state, variable load, thyristor-controlled type suitable for controlling fluorescent or incandescent lighting circuits operating at 230V +/- 6%, 50 Hz, single phase AC supply. Each dimmer shall be fully rated to carry the circuit loads continuously at any intensity level.

The lighting intensity shall be controlled by means of a knob or lever on the cover of the unit which shall provide smooth, even control of light from full brightness to moonlight glow. The units shall be suitable for surface mounting finished matt chrome with white circular or linear scale indicating the degree of brightness. Each dimmer shall be fitted with TV and radio interference suppressor. The dimmers shall be suitable for multi-phases connections and operation.

5.14 Ceiling and Wall Bracket Fans

Ceiling fans where called for shall be supplied with hook of the heavy-duty type complete with rubber bush and suspension rod of adequate diameter and appropriate length. Safety pin shall be provided to prevent any loosening of bolt and nuts or screws due to vibration.

Bracing of the rods at certain height and at both directions (lengthwise and breadthwise) to prevent wobbling where it is deemed to be necessary.

Motors shall be suitable for 230 Volt 50 Hz operation and of the multi-pole type with windings to Class E insulation. The casing shall be glass fiber reinforced polyester with flame retardant properties to local Authorities approval. Single or multiple regulators shall be provided as shown on the Design Drawings.

Blades shall be appropriately trimmed and corrosion free of the highest quality aluminum with epoxy polyester-coated for durability, white finish and of heavy-duty gauge.

Regulator for wall bracket fan shall be an integral part of the fan and with control for oscillating complete with three (3) speed and pull cord on/off switch.

5.15 OG Boxes

The weatherproof OG box shall be of hot moulded glass fiber reinforced polyester (GRP) of high impact strength of 80 kJ/m sq. with a rain hood top. The door shall be mounted on internal hinges with five points

latching system to IP 55. The total insulation shall comply with BS 5486 Part 1 and IEC 439 to withstand an ambient of 150°C. The OG box must be corrosion-proof, resistance against UV-light, chemicals, corrosive atmosphere, louvres with screen, etc.

The OG box shall be rigidly secured to its concrete base c/w PVC lead-in pipes, keys (3 sets), padlocking type of handle etc. colour and finish to be agreed by the Engineer.

5.16 Automatic Sensing Switch

Automatic sensing switch shall comprise movement presence detector, timer controller, relay unit and other necessary items as required for automatically switch on or off the lighting and air conditioning system after the controlled area is left unoccupied for a preset length of time (adjustable).

(i) Movement Presence Detector

The movement presence detector shall be capable of detecting presence of human beings in the area to be controlled. It shall be able to detect minute movements such as when a person is writing while seated at a desk. Each detector shall be furnished with a convenient by-pass provision which will enable the detector to be by-passed in the event of failure.

(ii) Timer Controller and Relay Unit

The timer controller and relay unit shall comprise time delay circuit and power relays suitable for switching 230V inductive circuit of current rating to suit the connected load. The time delay circuit shall be adjustable from 15 seconds to 15 minutes. An auxiliary NO/NC Voltage free contact shall be provided for connection to the fan coil unit control circuit.

The Contractor shall be responsible for the proper selection of the most appropriate presence detector to enable detection of the complete controlled area. Where necessary, more than one single detector operating in parallel shall be provided in order to achieve detection of the complete area.

5.17 Conduit Installation

Conduit installation for final circuits shall be in accordance with that specified for sub-mains distribution.

5.18 Wiring

Conduit installation for final circuits shall be in accordance with that specified for sub-mains distribution.

(i) Wiring within the false ceiling spaces, riser ducts, electrical switch rooms, sub-stations, mechanical plantrooms, for the lighting and power points shall be carried out using PVC or FR cables in Hot Dipped G.I. conduits/trunkings on the surface of the ceiling slabs/walls/columns etc. Conduits must be kept clear of gas and water pipes to Local Authority's requirements.

(ii) Wiring for all other areas for the lighting and power points shall be carried out using PVC or FR insulated cables in UPVC conduits, buried direct in wall plastering/columns/concrete slabs or concealed in partitions as appropriate. All concealed conduits shall be installed in accordance with the relevant clauses as specified elsewhere of this Specification.

5.19 Cable Termination Boxes

All cable termination boxes shall be fabricated from powder painted galvanized steel sheet with gasketed hinged doors and lockable handles. Each termination box shall be provided with both top and bottom openings of sufficient size to permit entry of the phase, neutral and earth cables. Each cable termination box shall comprise three numbers (phase, neutral and earth), 4-way branching connectors and numbers of HRC fuses and links of ratings as shown in the Design Drawings. The 4-way branching connectors shall be of brass silver material each complete with brass screws and locking washers and a polycarbonate transparent sealable cover mounted on a black polycarbonate mounted base. Each 4-way branching connector shall be suitable for connection of the main cables and outgoing cables of cross-sectional areas as specified in the Design Drawings.

5.20 Cellular Steel Floor Ducting System

The final distribution of wiring from the respective floor distribution boards, other special services located at finished floor level of the corresponding floors shall be through cellular steel floor ducts which will form part of the structural floor members of the building. Inactivated outlet boxes shall be provided as part of the cellular floor system at pre-determined locations as shown on the Design Drawings. All necessary components and accessories required for activation of the floor outlet and such as provision of single or twin switch socket outlets and wiring thereto, telephone outlets, internal mounting plates, top activating rings, cover assemblies etc., where called for on Design Drawings, shall be included under the Contract. Nylon draw wires shall be provided in all the cellular ducts to the requirements of the Engineer and/or the Authorities concerned to facilitate installation of cables at a later date. Where telephone and/or power points are required in the partitions as shown on the Design Drawings, floor taps shall be provided for running of wiring from the cellular ducts to partitions concerned; the floor tapes shall be finished nominally at concrete fill line and not above.

The entire cellular steel duct system at each floor shall be electrically continuous and earthed to the Building's electrical earthing system at suitable locations.

The cellular steel floor ducting system provided shall be approved by all the Authorities concerned i.e. The Electricity Department of Local Authority, etc. The Contractor shall be entirely responsible for obtaining these approvals and all costs connected therewith shall be deemed to have been included in the Contract.

5.21 Underfloor Duct Installation

PVC underfloor duct system suitable for use in the distribution of telephone and power services etc. within floor screed and finishes shall be provided in accordance with the layouts as shown on the Design Drawings. The system shall comprise single or multi-way extruded rectangular or trapeziform ducts made of rigid, non-corrodible, heavy gauge UPVC (unplasticized polyvinyl chloride), junction boxes c/w separators, multi-way vertical access boxes, pedestals, duct markers, direct outlets, outlet plugs, floor flange, blanking pieces, jointing sleeves, fixing clips, draw wires etc. similar to System 3100 manufactured by Gilflex-Key Ltd or equivalent. The power cables for 13 Amp floor socket outlets should not be drawn into the same duct as the telephone cables (by Telecom) and tunnel separators shall be provided in the junction boxes to ensure segregation of these two services; the proposed routing of all the power circuits within the underfloor ducts at each floor shall be submitted to the Engineer for review prior to installation.

Provisions shall be made such that services may be tapped off anywhere along the duct by direct outlet units, installed before or after floors have been screeded and finished and it shall be possible to abandon the threaded duct outlet units neatly flushed with the floor screed level. Ducts, junction boxes and vertical access boxes shall be accurately aligned and levelled and shall be adequately secured in place by means of purpose made fixing clips prior to screening of the floors; markers with acceptable colour scheme shall be provided at

intervals to identify the services in the ducts and similar colour PC disc shall be provided in the junction boxes for this purpose.

All joints in ducts and terminations of ducts in junction boxes/vertical access boxes shall be made water-tight with suitable sealing compound and precautions shall be exercised during construction to prevent damage to the duct system and to ensure that the ducts, junction boxes and vertical boxes are free of water, dirt, debris or any other obstruction which may impede and/or damage the cables during pulling-in. All metal parts of the duct system shall be effectively bonded to earth and earthing studs shall be provided in all the junction boxes and vertical access boxes for this purpose. Nylon draw wires acceptable to Telecom shall be provided in between every 2 adjacent junction boxes and between vertical access boxes to the nearest junction boxes to facilitate cable pulling at a later date.

Junction boxes and vertical access boxes shall be constructed as shown on the Design Drawings; blanking pieces shall be provided where required. Single or twin pedestals for telephone and 13 Amp switched socked outlets shall be of aluminum die castings finished hammer grey stove enamel suitable for horizontal flange mountings. All tools, fixing, accessories etc. including the manner of installation shall be strictly in accordance with the instructions/recommendations of the underfloor duct manufacturer.

5.22 Cast-In-Situ Flush Floor Trunking Installation

5.22.1 General

The flush floor trunking shall comprise of accessible triple compartments rectangular steel trunkings, three-way junction boxes c/w fixed flyovers, three-way vertical access boxes, pedestal outlets, couplers, levelling brackets, end caps, fixing brackets/clips, extruded PVC gaskets and all other necessary accessories suitable for the distribution of telecommunication, power and data cables separately in accordance with the layouts and sizes as shown on the Design Drawings. The system shall be proprietary make similar to 'Ega Slim-Line', Moduline Trenchduct or equivalent, suitable for cast-in-situ installation and flush with the monolithic reinforced concrete floors.

The system shall be designed for routing of telecommunication power and data cables in 3 separate compartments and suitable flyovers/separators shall be provided in all junction boxes to ensure proper segregation of different types of cables when crossing (at the same or different direction).

5.22.2 Earthing

The entire flush floor trunking network at each floor shall be electrically continuous and suitable earthing arrangement shall be made at the junction boxes for the installation of additional earthing cables under the Contract to achieve this. In addition, a proper earthing stud shall be provided at each of the vertical access boxes for connection to the electrical earth system by other contractors at a later date.

5.22.3 Construction

The trunkings with compartment separators, trunking flanges, etc., the junction boxes, the vertical access boxes, etc. shall be constructed from pre-hot dipped galvanized sheet steel to BS 2989 (1982) and BS 4678 Class3. The thickness of trunking body, compartment separators, flanges, junction boxes, vertical access boxes, etc. shall be not less than 1.6mm while all covers shall be not less than 2.5 mm thick. The trunkings and covers shall be of modular design in equal sections to facilitate installation and subsequent removal and replacement of covers for cable installation. The entire length of trunkings and junction boxes shall be accessible screws for fixing on trunking body. All accessories for the flush floor trunking system used shall be from the same manufacturer of the trunking system. Tap-off of any of the 3 services i.e. telecommunication, power and data shall be possible at any point along the trunking by drilling into the cover should not be pre-drilled. Special capping devices shall be available to seal/close up unused holes.

The internal surface of the trunkings shall have appropriate labels to identify the service cables i.e. Power, Telephone or Data Cables.

5.22.4 Installation

The entire flush floor trunking system including all tools and fixing accessories used shall be supplied and installed strictly in accordance with the recommendations/instructions of the manufacturer. The trunkings, junction boxes, vertical access boxes, etc. shall be properly aligned, levelled and secured such that the final alignment and level of the installation after the concreting of the floors are within the tolerable limits stipulated by the manufacturer. The Contractor shall liaise closely with the Main Contractor and make the necessary adjustments to allow for cambers and tolerances in the construction of floor slabs. All necessary supporting/fixing/levelling brackets shall be provided to affect the necessary adjustment. The limits of adjustment shall be compatible with the cambers and construction tolerances. Where steel bonder systems are used in the construction of the floor slabs, the Contractor shall ensure that the supporting systems for the trunkings are suitable/compatible with the bonder system. Precision instruments such as a theodolite shall be employed to ensure the correct installation of the system. All internal surfaces of the trunking system including the junction boxes and vertical access boxes shall be smooth and free from protrusions/sharp edges to prevent any damage to cables during installation.

Suitable extruded PVC gaskets shall be provided for the entire lengths of all the trunkings, junction boxes and vertical access boxes where the covers come in contact with any parts of the bodies of the trunkings, junction boxes and vertical access boxes, in order to prevent transmission of noise, ingress of dirt and water, etc. All joints in trunkings and all terminations of trunkings to junction boxes/vertical access boxes shall be made water-tight using a suitable type of sealant. Strict precautions shall be exercised during concreting of floor slabs and other building construction activities to prevent any damage to the trunking system.

The entire trunkings, junction boxes and vertical access boxes shall be kept free of water and dirt/debris at all times.

5.22.5 Pedestal Outlets

Pedestal outlets (which may be purchased later by the Employer) shall be manufactured from high pressure zinc alloy die-casting with epoxy powder coating of colours to the Engineer’s choice. The pedestal outlets shall be the single or twin type suitable for mounting of the standard single or twin switched socket outlet, telephone outlet or blanking plate as appropriate.

The pedestal outlets shall be suitable for horizontal flange mounting and shall be supplied completed with fixing accessories for mounting on the trunking covers.

5.22.6 Testing, Cleaning & Protection

The entire flush floor trunking system shall be tested for electrical continuity to the satisfaction of the Engineer and all necessary labour, instruments, etc. for such tests shall be included in the Contract. Before handing over the works, the entire flush floor trunking installation shall be dried and cleaned of all water, dirt/debris, etc. and the covers shall be protected with polythene sheets.

6. Busduct System

6.1 General

Busduct System shall be consisting of vertical and horizontal busducts of proprietary make of copper (material type as specified in the drawings) busbar type with continuous dedicated internal earth bar – 5 bars configuration enclosed in steel sheet trunking and shall have the current ratings as shown in this Contract.

The Busduct System shall be proposed to suit for the environment in this Contract, requirement of a min IP 65 or totally waterproof shall be adhered whether the environment call for particularly in sprinkler protected spaces and exposed to external weather even in sheltered areas.

Weatherproof Busduct System where deem to be required by the environment in this contract shall incorporate gaskets, drain holes etc. suitable for outdoor installation.

Cast resin type busduct shall be provided where car park and atmospheric pollution areas as per IEC 61439 (1 & 6)

The Busduct System shall be slim designed and of low impedance type and shall operate on 230 / 400 V at 50 Hz and shall be manufactured in compliance and accordance to BS EN 61439-6, and of equivalent other international standards and is type tested and certified. All material, components and accessories (such as elbows, joints, flange end / flange end box, tap-off units, end cap, expansion units, seismic mounting accessories, etc.) used for the complete Busduct System shall be of the same origin of manufacture.

6.2 Busduct Construction

The Busduct enclosure shall be made of electro-galvanized sheet steel coated with epoxy powder paint to a grey colour or the nearest manufacturer's colour of standard production. Phase indication of busduct system shall be provided on the busduct metal enclosure.

The construction shall be of folded mild steel channel construction, of not less than 2mm. The casing ends shall be identical to minimize the fittings required and to simplify installations. A splice plate shall be furnished at each joint to mechanically join the casings assembly.

Busbars assemblies shall be suitably enclosed, vermin and insect proof and designed to prevent unauthorized access to live metal. Busducts shall be supplied complete with all external galvanized steel supports and brackets suitable for fixing to walls/ceiling.

All metal works shall be treated against corrosion, painted with primer undercoat, and finished with grey synthetic enamel. Metal casings shall be treated to prevent corrosion and finished in the same manner as the busbar trunking. Red oxide primer shall be used for steel casing, and the remaining steelwork including machine parts are to be sherardized or subjected to an equivalent process.

The Busduct System shall be able to accept tap-off units of current ratings up to not less than half the current rating of the busbar trunking.

Expansion units shall be capable of taking up the thermal expansion or contraction when busduct system operates at full rated current and the ambient temperature changes. In particular, expansion units shall be provided where both ends of the busduct are fixed and where the busduct is installed across a building expansion joint.

Internal Earth bar (non-insulated) size per Design Drawings of phase bus bars shall be provided inside the busduct enclosure. Busduct system shall be terminated by end cap / end closure.

6.3 Rating

The complete Busduct System shall be capable as a whole of withstanding the short circuit capacity to the electrical installation without damaging by the electrical, mechanical and thermal stresses produced under a short circuit condition equivalent to the respective protective circuit breaker kA rating as shown on the Design Drawings at 400 Volt for 3 seconds as defined in BS 5486 unless otherwise specified.

6.4 Busbars

Busbars shall be of rectangular cross section HDHC copper, having current ratings in accordance with BS 5486 for a temperature rise not exceeding 40-degree Celsius and shall be fully insulated with a thick layer of continuous seamless PVC and further wrapped with non-ageing glass filled polyester film with good heat conducting properties. Busbar trunking of 300 Amp rating and below may be of the air insulated type but shall be totally enclosed in steel trunking.

High grade insulators shall be used to support the busbars. Full size neutrals shall be provided for all busbar trunkings. Phase indication of busbars shall also be provided. All busbar trunkings shall be built to withstand expansion and contraction and shall be capable of operating continuously at rated current for ambient temperature not exceeding 40-degree Celsius without derating.

Busbars supports shall be suitably insulated and Ample clearance shall be allowed between conductor surfaces and busbar casing. Insulation materials shall be of high-resistivity, non-hygroscopic, non-ignitable, non-tracking, strong and so shaped to avoid accumulation of dust and dirt.

Busbars forming long stretch run shall include proprietary made expansion joints. Such joints shall be the laminated copper having current carrying capacity not less than that of the conductors to which they are attached. Movement of the expansion joints or of conductors shall not encroach on a minimum clearance required.

6.5 Joints

Joints shall be accomplished by means of an insulated bolt passing through conductors. Joints shall not be affected by deforming the casing. Inspection covers shall be provided on each side of the joint and shall be usable without disturbing the joint pressure.

Contact surfaces in busbar joints, ends, and tap-off points shall electrolytically tinned all over and joints shall be properly tightened. Proprietary make standard bend, elbow and tee units of correct sizes shall be supplied complete with all fixings necessary for assembly with straight lengths of Busduct System. Samples of the units shall be submitted to the Engineer for review prior to installation.

It shall be possible to tighten a busduct joint from one side in the event of the busduct is installed against a wall or ceiling. All bolts shall be tightened up by means of a torque wrench to a strength figure as recommended by the manufacturer.

For Waterproof, Weatherproof and Fire Rated Busduct System, the jointing integrity shall abide with its full application properties.

6.6 Fire Barrier and Fire Ratings

Fire-resisting barriers of 2 hours fire rating shall be incorporated in the Busduct System whenever the busbar trunking passes through floor slabs or fire rated walls; min 2 hours or more fire resisting barriers shall also be provided around (external) the Busduct System trunking shall be Fire Rated compliant to the requirement Fire Compartmentation of the building, and to local authorities requirement.

Fire Retardant Busduct System shall be fire retardant for Essential Services, and where it runs into another Fire Compartmentation Spaces as defined by the local Architects.

Fire Rated Busduct shall be provided for all circuitries incoming and outgoing from the Emergency Main Switchboard. The conductors of Fire Rated busduct shall be insulated with double layers of mica tape and polyester films. All joint sections shall be protected with fire protective materials.

The rating of fire rated Busduct System shall suit the Fire Protection environment.

Both Busduct straight feeds and Busduct joints shall be type-tested for fire resistant IEC 60331, BS 6387 with Fire Rating of 950 degree C and testing methods adopted by independent testing authority. Type test certificates shall be submitted for approval / endorsement.

The whole of the Busduct System shall be type tested and certified by A.S.T.A., K.E.M.A. or other recognized National or International Testing Authority. Test reports are to be submitted in Technical Submission.

6.7 Conductor

6.7.1 Copper Conductor

The conductors shall be three phases with full size neutral and internal earth made of hard drawn high conductivity solid copper bards to, ASTM B187M, BS EN 13601 and other relevant quality standards. The conductors shall be silver or tin plated at all electrical contact surfaces.

The cross-sectional area (CSA) of copper conductors shall be in accordance to the following table as a minimum.

Current Carrying Capacity (A)	CSA (mm^2)
600	240
800	300
1000	450
1200	600
1500	750
1600	900
2000	1110
2500	1500
3200	1800
3500	2100
4000	2250
4500	2700
5000	3150
6000	3330

The maximum operating temperature of busduct system shall comply with IEC 60439-1 and IEC 60439-2. The temperature rise at any points of the insulated conductors shall not exceed 70°C above ambient temperature when operating at rated load current. Busduct System shall be able to operate at full rated current at a maximum ambient temperature of 40 °C without derating.

6.7.2 Aluminium Conductor

The conductors shall be three phases with full size neutral and internal earth made of aluminum bars (Grade 1070, 99.7% purity). The conductors shall be silver or tin plated at all electrical contact surfaces.

The cross-sectional area (CSA) of aluminum conductors shall be in accordance to the following table as a minimum.

Current Carrying Capacity (A)	CSA (mm^2)
600A	300
800A	450
1000A	600
1200A	750
1500A	900
1600A	1110
2000A	1440
2500A	1800
3200A	2220
3500A	2880
4000A	3150
4500A	3330
5000A	4320

6.8 Flange End / Flange End Box

Flange end or flange end box shall be provided for each Busduct System. The rated current and rated short-time withstand current of the flange end shall not be less than that of the Busduct System to which it is connected.

The removable bottom cover of flange end box shall be made of non-ferrous material for the ease of cable termination works.

Where connections are to be made to a switchboard or transformer, flange end shall be coordinated, such that the phase sequences at connected switchboard and transformer are matched. Bi-metal plates are recommended for the connections of copper and aluminum materials.

Braided type of copper flexible link bar shall be connected between the transformer LV terminals and busduct flange end. Laminated type of flexible link bar shall not be acceptable.

6.9 Feed-In Units, Tap-Offs and Tap-Off units

Tap-off units shall be of the same manufacture as Busduct System, comprising MCCB, MCB, HRC fuses and neutral link with circuits' ratings as indicated on the Design Drawings. The short circuit breaking capacities of the MCCB, MCB and HRC fuses shall not be less than the maximum prospective fault level at the point where the tap-off unit is installed. All HRC fuses must be in accordance with British Standards and of the type readily available locally. HRC fuses of other standards will not be accepted.

Tap-off units shall be proprietary make, totally enclosed in casings having securely fastened hinged covers, and provided with screwed conduit entries or cable glands as required to suit the type of cables used. Glands or cable entries are to be located in either base, back or sides of the units as required to suit site conditions.

Tap-off units shall be the plug-in type suitable for all sizes of busbars with adequate contact pressure. Beams shall be provided for fixing the casing to the Busduct System. All tap-off units shall be suitably earthed. The earthing contact shall always be made before that of the active conductors.

For Vertical Busduct System, provisions shall be made in the Busduct trunking for tap-off units at intervals of 600 mm; tap-off points where not used shall be provided with proper outlet covers. Tap-off openings shall be of the safely type and in conjunction with the tap-off units shall have interlocks provided which prevent additions or removal of the tap-off unit when the switching mechanism is in the 'ON' position. Metal parts of the tap-off units shall be designed to contact the steel casing before the plug fingers contact the busbars. 'Danger' warning signs shall be provided at all tap-off points. Feeder busbar trunkings utilized for the interconnection between transformers and the main switchboards shall not be provided with tap-off points.

Busbar System on terminal floors shall have sufficient length for installation of at least 3 tap-off units on each terminal floor at the specified interval.

Tap-off units shall be used for branch circuits taken off from the Busduct system. Every tap-off unit shall be of manufacturer's proprietary product to match and to be an integral part of the Busduct System.

Moulded case circuit breaker (MCCB) complying with IEC 60947-2 of appropriate current ratings and short circuit breaking capacities shall be provided as near as practically possible to the tapping position for protection of the branch circuits.

Tap off units shall be equipped with internal barriers to prevent accidental contact with the live parts at the terminals of the protective device.

Tap-off units shall make positive ground connection to the Busduct housing before the plug-in clips make contact to the phase conductors.

Mechanical interlock of rotary handle type shall be incorporated to prevent installation or removal of tap-off nit while the MCCB is in the "ON" position.

Plug-in holes on the busduct system for tap-off units shall be equipped with phase isolator to segregate the tapping position of each phase of the busduct system. For aluminum busduct, the contact part of aluminum conductor shall be protected with a piece of tinned copper sheet.

Tap-off units shall be complete with a removable bottom cover for the ease of cable termination works.

"Danger" warning signs of an approved type shall be provided at the front panel of all tap-off units.

6.10 Mounting method

The vertical busduct system shall be supported adequately by vertical spring hanger / vertical hanger mounted on channel base of each floor. Intermediate supports shall be provided if the floor height exceeds 5000 mm.

The horizontal busduct system shall be supported by horizontal hangers at every interval of 1500 mm.

6.11 Requirement for Air-Insulated Busduct System

a) Busduct Enclosure

Enclosure of the busduct shall be rigidly constructed from electro-galvanized sheet steel of not less than 1.5 mm thickness, formed in such a way as to give a rigid structured of sufficient strength. Both the main portion of the enclosure and cover shall be flanged at the side edges.

b) Conductor Supports

Conductors shall be supported on insulated racks or blocks to IEC 60667 and IEC 60439-1. The conductor supports shall be mechanically strong to withstand the force between the conductors produced by a short circuit between two or more conductors.

6.12 Requirement for Fully Insulated Compact Sandwich Busduct System

a) Busduct Enclosure

The enclosure of the busduct shall be rigidly constructed from electro-galvanized sheet steel of not less than 1.5 mm thickness and clamped on the rigid side of steel frames by means of bolts and nuts.

The assembly of the steel frames shall consist of not more than two seams to enhance the mechanical strength of the busduct enclosure.

The external surface of busduct enclosure shall be coated with epoxy powder paint finish.

b) Conductor Insulation

Conductor shall be insulated over their entire length expect at joints and plug-in contact positions. The insulation materials shall be “Mylar” polyester film insulation that meets the requirement of Class B material (130 $^{\circ}$C) with the insulation Voltage of 1000 V.

c) Busduct Joints

The busduct joint shall be of the double-bolt joint design coupled with a pair of leaf springs to ensure sufficient electrical contact and mechanical strength.

Bolt-through joint design and joint stack design shall not be acceptable.

The joint shall be covered up by metal cover plates of same type of material and finishes as the busduct enclosure.

6.13 Acceptance Tests at Manufacturer’s Works

Completed Busduct System shall be visually inspected for technical execution and conformity with the latest issue of the approved drawings and with the order. Spot checks shall be made to verify:

(1) Outline dimension of busduct enclosure

(2) The degree of protection of the enclosure

(3) Creepage distances and clearances

(4) Proper mounting of components.

(5) Internal connections

(6) The availability of the earth points for connection

(7) Measurement of insulation resistance (Megger Test) on the conductors

(8) Dielectric test shall be carried out with 2.5 kV rms for 1 minute

(9) Testing of the mechanical and electrical operation of a number of functional units on a random basis

6.14 Type Testing and Certification

ASTA type test certification to latest edition of BS EN 60439-6 shall be submitted to the Engineer for approval.