The Comparative Tracking Index (C.T.I.) shall be determined on all organic material insulators, and other insulating material as directed by the Engineer. The test method on any electrical materials intended for use outdoors or in servers ambient conditions shall be in accordance with IEC 587, and materials not exposed to such conditions shall be tested in accordance with IEC 112.

Insulator and bushings of moulded or resin bonded material shall be identified with the manufacturers mark and batch identification. Such marking shall not impair the electrical properties of the surface finish.

Insulators and bushings, shall be mounted, and the method of attaching connections be such, that there is no likelihood of their being mechanically overstressed during normal tightening of the mounting and connection fixings. Similar provision shall be made to accommodate expansion and contraction of the connections having regard in the temperature likely to be attained during fault conditions. Mountings shall be of sufficient strength and rigidity to withstand the forces created by the passage of maximum prospective short-circuit current with full asymmetry, without permanent damage or permanent deflection sufficient to reduce electrical performance of insulation strength.

7.6.33 Electrical Insulation

Insulating materials shall be suitably finished so as to prevent deterioration of their qualities under the specified working conditions. Account shall be taken of the IEC 85 and IEC 505 recommendations.

Ebonite, synthetic resin-bonded laminated material and bituminized asbestos cement-bonded panels shall be of suitable quality selected from the grades or types in the appropriate British, IEC, or approved National Standard.

All cut or machined surfaces and edges of resin-bonded laminated materials shall be cleaned and then sealed with an approved varnish as soon as possible after cutting.

Linseed oil and untreated materials of fiber, leatheroid, presspahn, asbestos or other similar hygroscope types of materials shall not be used for insulation purposes. Untreated leatheroid and presspahn may be used for mechanical protection of winding insulation.

Wherever practicable, instrument, apparatus and machine coil windings, including wire wound resistors, with the exception of those immersed in oil or compound, shall be thoroughly dried in a vacuum or by other approved means and shall then be insulating varnish. Varnish with a linseed oil base shall not be used.

No material of a hygroscope nature shall be used for covering coils. Where inter-leaving between windings in coils is necessary, only the best manila paper, thoroughly dried, which permits penetration by the insulating varnish or wax, shall be used.

7.6.34 Insulating Oil

Insulating oil shall comply with the requirements of IEC 296. Insulating oil shall be provided by the Contractor for all oil-filled apparatus and 10% excess shall be provided for topping up purposes in sealed drums. The Contractor shall satisfy himself that suitable oil treatment facilities are available at Site for his use. If the Contractor is

unable to obtain written assurances to this effect he shall provide such oil treatment facilities as required to meet the specification, at no additional cost.

7.6.35 L.V. Circuit Protection

Fuses are not to be used for protection of circuits below 1000V phase-to-phase, (Low Voltage).

All low voltage and dc circuit protection is to be provided by moulded case, or miniature circuit breakers.

Link carriers and bases shall be of an approved manufacture and of such form and material so as to protect persons from shock and burns in normal service and maintenance. Links, and fixed contacts shall be shielded to prevent inadvertent contact with live metal whilst the link is being inserted or withdrawn.

The labeling of carriers and bases shall comply with IEC 269 Identification labels fixed to panels, boards and desks for MCBs and links shall describe their duty, voltage and rating.

7.6.35.1 Miniature Circuit Breakers

All miniature circuit breakers (MCBs) shall comply with IEC 157 and be fitted with over-current releases of both the thermal and instantaneous type. All MCBs supplied on this contract shall be to short circuit category P2 of IEC 157.

Single, two or three pole breakers may be used where appropriate and a trip of one pole shall cause a complete trip of all associated poles. In addition the rating given of MCBs supplied shall be confirmed as that appropriate to the enclosure provided.

The Contractor shall ensure satisfactory time and current grading with other associated miniature circuit breakers or MCCBs.

7.6.35.2 Distribution Boards And Isolators

Distribution boards shall be provided throughout the plant for local distribution of lighting, small power and air conditioning supplies. The lighting and small power circuits may use a common distribution board.

Distribution boards shall be of 1 kV a.c., 1.2 kV d.c. rating and conform to IEC 439. All distribution boards shall be of the weatherproof enclosure type and shall be arranged so that the door or cover can be locked in the closed position.

All triple pole and neutral boards shall provide satisfactory cable entry for all cables which could be required for the number of circuit facilities provided and shall have the neutral bar drilled for the full number single phase ways.

Each distribution board supplied from a remote location shall have a load breaking/fault making incoming isolating switch mounted adjacent to or as part of the distribution board. Each distribution board shall have removable top and bottom (undrilled) gland plates.

Each circuit in every distribution board shall be numbered and identified by means of a schedule attached to the interior of the door or cover of the board. The schedule shall be legible and durable to the Engineer" approval.

Twenty-five percent spare ways shall be provided for future use.

7.6.36 Electrical Equipment, Instruments and Meters

- All instruments and meters shall be fitted with glasses of low reflectivity and shall not cause pointer deflection due to electro-static charging through friction.
- All indicating instruments shall be of the flush mounted pattern with dust and moisture proof cases complying with BS. 2011, Classification 00/50/04, and shall comply with BS. 89:1977 or IEC. 51.
- Unless otherwise specified, all indicating instruments shall have 95mm square cases to DIN standard or equivalent circular cases.
- Instrument dials in general should be white with black markings and should preferably be reversible where double scale instruments are specified.
- Scales shall be of such material that no peeling or discoloration will take place with age under humid tropical conditions.
- The movements of all instruments shall be of the dead beat type.
- Instruments shall be provided with a readily accessible zero adjustments.
- The mounting height of the centre of all indicating instruments shall not exceed 2000mm.
- A.C. ammeters for transformer, feeder or inter connector circuits, and D.C ammeter for all load circuits except motors, shall have linear scales commencing at zero.
- A.C and D.C ammeters for motor circuits shall have scales commencing at zero and with a compressed overload portion for reading of the associated minor starting current.
- D.C. ammeters for the main battery circuit of D.C systems shall have scales with positive and negative ranges, labeled charge and discharge respectively.
- Voltmeters for feeders and transformer circuits shall have expanded scales to display the nominal service voltage ± 20%.
- Wattmeter for feeders shall have linear positive and negative reading scales to be approved.
- Varmeters for all circuits shall have linear positive and negative reading scales to be approved.
- Frequency meters shall be of the pointer type, scaled approximately 45-55Hz, and biased to swing to one end of the scale on loss of voltage.
- Synchronizing voltmeters shall be scaled in per unit values only, to correspond to the above expanded voltmeter scales.
- Synchroscopes should be continuously rated, but if not then at least 30 minute rated with an individual on/off switch.
- The synchroscopes shall indicate synchronism between two circuits with the pointer at the "12'0'clock" position only, and shall have arrows on the face to show that the frequency of the "incoming" supply is fast or slow with respect to the "running" supply. The synchroscope switch shall disconnect both supplies to the instrument and the instrument pointer shall move at least 45^0 from the vertical position when either or both supplies are removed and shall then remain stationary without any tendency to creep.
- In addition all synchroscopes shall include two synchronizing lamps. These lamps shall be "bright" for synchronized conditions, but are to act solely as a supplementary indication that may be used by the operation with caution in the event of failure of the synchroscope.
- Integrating metering shall be provided where indicated on the specification drawings. These meters shall be of the withdrawable flush mounted type and comply with the relevant parts of IEC 521 and BS 5685, Class 1.0 accuracy and BS 37, Part 9. The meters shall include cyclometer dial type registers.
- Approved test terminal blocks of the three-phase type shall be provided for connecting in circuit with each meter a portable testing meter.

- Recording instruments shall be of an approved type, and unless otherwise specified, shall have two chart speeds of 25 mm and 50 mm per hour available for selection by means other than changing connections. They shall be complete with sufficient charts and inks for two years' working.
- All instruments, meters, recorders and apparatus shall be capable of carrying their full load currents without undue heating. They shall not be damaged by the passage of fault currents within the rating of the associated switchgear through the primaries of their corresponding instrument transformers.
- All instruments, motors and apparatus shall be back connected and the metal cases shall be earthed.
- All voltage circuits to instruments shall be protected by a fuse in each unearthed phase of the circuit placed as close as practicable to the main connection.
- All power-factor indicators in 3-phase circuits shall have the star point of their current coils brought out to a separate terminal which shall be connected to the star point of the instrument current transformer secondary windings.
- All instruments and meters associated with multi-ratio CT's shall be provided with sets of scales etc. appropriate to each CT ratio. It shall be possible to replace the scales of instruments without dismantling the instruments or interfering with any tropicalization finish.
- The Contractor shall provide electrical instrument and meter schedules to include, manufacturer, type, designation, current and voltage rating, accuracy class and circuit designation.

7.6.37 Control and Selector Switches

Control switches shall be of the three-position type with a spring return action to a central position (and without a locking feature).

Circuit breakers shall have control switches which shall be labeled open/N/close or (O/N/I and arranged to operate clockwise when closing the circuit breakers and anti-clockwise when opening them, and shall be of the pistol grip type.

Control switches of the discrepancy type shall be provided where specified, i.e. mimic panel. Such discrepancy control switches shall be arranged in the lines of the mimic diagram. Such switches shall include lamps and be of the manually operated pattern, spring loaded such that it is necessary to push and twist the switch past its indicating position for operation. The lamp shall be incorporated in the switch base and shall flash whenever the position of the circuit breaker is at variance with the position indicated by the control switch. Hand dressing of the control switch to the correct position shall cause the lamp to extinguish.

Selector switches shall be of the two or more position type as required, and have a stay-put action to remain in any selected position which shall be lockable (separate padlocks each with duplicate keys should be provided). Each position of the selector switches shall be suitably labeled to signify their function. The switch handle shall be of the pistol grip type to the approval of the Engineer.

It shall not be possible at any time to operate any switchgear equipments from more than one location simultaneously, and suitable lockable selector switches shall be provided to meet this requirement.

The contacts of all control and selector switches shall be shrouded to minimize the ingress of dust and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

7.6.38 Auxiliary Switches

Auxiliary switches shall be to approval and contacts shall have a positive wiping action when closing.

All auxiliary switches, whether in service or not in the first instance, shall be wired up to a terminal board and shall be arranged in the same sequence on similar equipments.

Auxiliary switches mechanically operated by the circuit breakers, contactors, isolators, etc. shall be to approval and contacts mounted in accessible positions clear of the operating mechanism of the circuit breaker, contactor, isolator, etc., and they shall be adequately protected against accidental electrical shock.

Auxiliary switches shall be provided to interrupt the supply of current to the trip coil of each circuit breaker and contactor immediately the breaker or contactor has opened. These auxiliary switches shall make before the main contacts, during a closing operation.

A minimum of four spare auxiliary switches, two normally open, two normally closed shall be provided for each circuit breaker, and contactors and also for isolators.

7.6.39 Transistorized Electronic Equipment

Transistorised electronic equipment shall comply with the BS 9000 series or equipment National specification and be adequately sized and derated to suit the local climatic condition.

Wiring boards shall comply with BS 4584 part 2. Unless otherwise approved, epoxy resin-bonded fiberglass boards shall be used. The conductors shall be not less than 0.4 mm with the standard spacing for voltage 0.5 to 4 volts (Peak)

External connections from the boards shall be soldered, crimped or through plug and socket connections to approval.

The identification of components in boards shall comply with BS 9000 or equivalent National specification and the identification of individual boards shall be agreed with the Engineer.

Where boards are mounted in racks they shall conform to 483 mm wide module unless otherwise agree. The location of individual boards within the racks shall follow a logical pattern, boards for similar duties being arranged in similar order.

7.6.40 Alarm Equipment

Where an alarm system is specified, it shall consist of an initiating device, a display unit and push buttons mounted on the front of the appropriate control panel, together with a continuously rated audible warning device flasher unit and relays. The relays shall wherever possible, be mounted inside the same panel; where the number of alarms to be displayed makes this impracticable, a separate alarm relay cubicle or cubicles will be considered as an alternative.

Where it is necessary to differentiate between the urgency of alarms then various approved alarm tone devices shall be provided in this Contract. In addition and where specified an alarm beacon to the approval of the Engineer shall be provided.

The display unit shall consist of a rectangular frame or bezel enclosing the required number of individual facias, each of which shall be preferably approximately 32mm x 25mm in size. Each facia shall be in the form of a window inscribed with the specified legend, describing the fault condition to be indicated. Lamps shall not illuminate adjacent windows.

At least 3 spare ways shall be provided on each display unit. All unused ways in a display unit shall be fully equipped and the alarm system designed to enable these ways to be utilized at a future date.

Alarm relays shall be of a type to the approval of the Engineer, arranged to plug into fixed bases, either singly or in groups and have positive means of retaining them securely in the service position, the bases being mounted on racks or frames which shall be hinged to allow them to be swung clear of the sides of the panel or cubicle in which they are installed in order to provide ready access.

The type of wiring used for internal connections between alarm facias and their relays and between relays and terminal blocks, shall generally comply with these requirements with the following exceptions:-

(i) Single-strand wire, not less than 0.85 mm in diameter may be used.

Soldered terminations will be acceptable

External connections for alarm circuits will in general be run in multi-core cables having a larger core size than that referred to above. This will necessitate special terminal blocks, if soldered terminations are used, in which case the internal and external terminations of each pair shall be joined by a removable link. Samples of the type of wire and terminal block to be used for alarm connections shall be submitted for the Engineer's approval.

The operation of the alarm system shall be as follows:-

When an external alarm indicating contact closes the audible warning shall sound continuously and the appropriate facia shall be illuminated by a flashing light at a frequency which allows the inscription to be easily road.

An 'Accept' push-button shall be provided on or near the display unit, which when pressed, shall silence the audible signal and cause the facia to remain illuminated steadily.

The alarm circuit shall be designed to retain the indication after the re-opening of the initiating contact, requiring a separate 'Reset' push button to be pressed before the alarm is cancelled

A 'Test' push button shall be fitted close to the 'Accept' and 'Reset' buttons, to illuminate all the facias on the associated display unit for as long as the 'Test' button is held depressed.

The operation of the 'Accept' button shall not preclude the receipt of further indications giving more audible alarm and visual indications as the result of the operation of other sets of alarm contacts.

Relays shall not be continuously energized when the alarm system is at rest.

For all alarm indication initiating device a spare set of voltage-free contacts shall be provided (this may be by the use of auxiliary relays) and connected by cable to a suitable, approved marshalling cubicle. These spare contacts will provide for the transmission of the alarm indication signals to the remote Grid Control Centre.

The Contractor shall be responsible for providing all the alarms required for the safe and efficient operation of the plant. General descriptions of alarms requirements are given in the specification, and the Contractor shall include any other alarms that are necessary due to the type of equipment and design of the plant to the Engineer's approval.

7.6.41 Current Transformers (CTs).

The current transformer rated current ratio shall match the connected load circuit and secondary circuit requirements.

Current transformers shall be capable of withstanding without damage the full load, peak and rated short time currents of their associated equipment.

Where space within a current transformer chamber permits dedicated current transformers shall be used for protection, instrumentation and metering.

Current transformers for protective and protective/indication purposes shall be designed to suit the particular requirements of the associated protection, which in general shall be in accordance with the recommendations given in BS 3938 or approved equivalent.

Class 5p current transformers shall be used for inverse time over-current and/or earth fault protection. The rated accuracy limit current shall be equivalent to the maximum symmetrical three phase fault current or earth fault current of the protected circuit or equivalent tot he switchgear breaking capacity unless otherwise approved by the Engineer. The current transformers shall be capable of meeting the 5p error classification at rated accuracy limit current over the full range of relay settings, unless otherwise approved by the Engineer.

Current transformers used for indication/metering purposes shall be designed to saturate at a value of primary current sufficiently low to protect the secondary circuit from damage at all possible values of primary fault current up to the associated primary short time thermal rating.

Current transformers for protection using high impedance relays shall be of the low reactance type and their performance shall be stated in terms of the Class X parameters of BS 1938. (Low reactance current transformers may be shown to be low reactance by virtue of their construction as defined in Clause 4.4.2.21. of BS 3938.

If all the constructional requirements are not met then type tests will be required to prove that the current transformers are low reactance; the primary test current shall not be less than the through fault (stability) current of the protection scheme.

The rated volt-amp output of each current transformer shall not be less than 110% of the connected burden as installed in service, the burden of cable connections being taken into account.

The secondary windings of each set of current transformers shall be earthed at one point only via an accessible bolted disconnecting link, preferably located within the relay cubicle.

Where double-ratio secondary windings are specified provided a label shall be provided at the secondary terminals of the current transformer indicating clearly the connections required for either tap. The connections and the ratio in use shall be indicated on all connection diagrams.

Design magnetization curves and d.c resistance values shall be submitted before manufacture for each current transformer used for protective purposes and shall be subsequently verified by works routine tests and also by site commissioning tests.

Where current transformers have to operate or be mounted on apparatus provided under other contracts, the Contractor shall be responsible for ensuring design and installation compatibility with other Contractors and for keeping the Engineer informed.

Metal clad switchgear current transformers shall be located on the non-bus-bar side of the circuit breaker except where current transformers are provided on both sides of the circuit breaker for protection zone overlap. The primary conductors shall be accessible for primary current injection treating on site.

7.6.42 Voltage Transformers (VTs)

Voltage transformers shall comply with the requirements of IEC 60044-2 with amendments and supplements and shall be of:-

Class 3p accuracy for protection/indicating instruments

Class 0.2 accuracy for tariff metering or acceptance efficiency testing.

For tariff metering voltage transformers the Contractor shall check the total installed secondary burden and if necessary shall install dummy burdens to achieve the calibrated accuracy.

Voltage transformer secondary circuit shall be earthed at one point only and metal cases shall be separately earthed. The transformers core, where accessible, shall also be separately earthed.

All voltage transformers in the system at a given voltage level shall be earthed in the same manner.

Where it is required to earth the primary neutral of a metal clad three- phase voltage transformer, the neutral earthing connection shall be insulated and brought out separately from the tan earthing connection. Means shall be provided to maintain the tank earthing connection while the voltage transformer is being withdrawn.

Where three single-phase voltage transformers are supplied for protection purposes star connected secondary windings shall have the star point formed by insulated connections and shall be earthed at a common point.

Where possible primary windings shall be connected through fuses with current limiting features.

Secondary MCB's shall be provided as close as possible to each voltage transformer and labeled to show their function and phase colour. The secondary circuits shall be monitored individually to detect and alarm individual fuse failure or MCB trip and to block protection operation if required.

Voltage transformers shall be designed that saturation of their cores does not occur when 1.732 times normal voltage is applied to each winding.

Magnetization curves shall be submitted for approval for each type of voltage transformer.

The standard secondary voltage between phases shall be 110 volts unless special circumstances dictate otherwise, and are approved by the Engineer.

Secondary circuits from different voltage transformers, or separate windings of the same transformer, shall not be connected in parallel.

Voltage transformers shall be connected on the non-busbar side of circuit breakers unless otherwise approved by the Engineer.

7.6.43 Panels, Desks, Kiosks and Cubicles

7.6.43.1 General Requirements

Unless otherwise specified, panels, desks and cubicles, shall be of floor-mounted and free-standing construction and be in accordance with the specified enclosure classification. All control and instrumentation panels shall be identical in appearance and construction.

Panels shall be rigidly constructed from folded sheet steel of adequate thickness to support the equipment mounted thereon, above a channel base frame to provide a toe recess. Alternatively a separate kicking plate shall be provided.

Overall height, excluding cable boxes, shall not exceed 2.5 m. operating handless and locking devices shall be located within the operating limits of 0.95m and 1.8m above floor level. All panels shall be fitted with padlocks. The minimum height for indicating instruments and meters shall be 1.5m unless otherwise specified.

All panels' desks and cubicles shall be vermin and insect proof. All cable entries to equipment shall be sealed against vermin as soon as possible after installation and connecting-up of the cables to the approval of the Engineer.

Ventilation shall be provided for natural air circulation. All control equipment shall be designed to operate without forced ventilation.

For outdoor equipment, metal to metal joints shall not be permitted and all external bolts or screws shall be provided with blind taped where a through hole would permit the ingress of moisture. All metal surfaces shall be thoroughly cleaned and particular care taken during painting to ensure that both internally and externally a first class cover and finish is achieved. For harsh environments, all nuts, bolts and washers shall be plated.

Door sealing materials shall be provided suitable for the specified site conditions. Doors shall be fitted with handles and locks. The doors shall be capable of being opened from within the panel without the aid of a key after they have been locked from the outside. Hinges shall be of the life-off type. Seals shall be continuous or with only one joint.

The bottom and/or top of all panels shall be sealed by means of removable gasketted steel gland plates and all necessary glands shall be supplied and fitted within the Contract.

Panels shall be suitably designed to permit future extension wherever appropriate or specified without the need to dismantle the existing panels.

Each panel shall include rear access doors and door-operated interior lamp, and be clearly labeled with the circuit titled at front and rear, with an additional label inside the panel. Panels sections accommodating equipment at voltages higher than 110 V shall be partitioned off and the voltage clearly labeled. Each relay and electronic card within panels shall be identified by labels permanently attached to the panel and adjacent to the equipment concerned. Where instruments are terminated in a plug and socket type connection both the plug and the socket shall have permanently attached identifying labels.

Instrument and control devices shall be easily accessible and capable of being removed from the panels for maintenance purposes.

For suites of panels inter-panel bus wiring shall be routed through apertures in the sides of panels and not via external multi-core cabling between the panels.

All panels, whether individually mounted or forming part of a suit, shall incorporate a common internal copper earthing bar onto which all panel earth connections shall be made. Suitable studs of holes to the Engineer's approval shall be left at each end of the bar for connection to the main station earthing system.

Earth connection between adjacent panels shall be achieved by extending the bar through the panel sides and not by interconnecting external cabling.

Cubicles and cubicle doors shall be rigidly constructed such that, for example, door mounted emergency trip contacts can be set so that mal-operation will not be possible due to any vibrations or impacts as may reasonably be expected under normal working conditions.

7.6.43.2 Indicating Lamps

All new indicators shall have a minimum continuous burning guaranteed life of 10000 hrs, at their rated voltage.

Indicators shall be of the filament lamp, LED or preferably Neon type and shall be approved by the Employer.

Indicators shall be easily replaceable from the front of the panel and. shall be adequately ventilated. LED indicators shall operate at not less than 20mA and red LED indicators shall be of the high brightness types.

The lamps shall be clear and shall fit into a standard form of lamp holder. The rated lamp voltage should be ten percent in excess of the auxiliary supply voltage, whether AC or DC. Alternatively, low voltage lamps with series resistors will be acceptable, however resistors shall be dimensioned to avoid damage due to heat.

The lamp glasses shall comply with BS. 1376 and BS. 4099 or equivalent National Standard and shall be in standard colours, red, green, blue, white and amber. The colour shall be in the glass and not an applied coating and the different coloured glasses shall not be interchangeable. Transparent synthetic materials may be used instead of glass, provided such materials have fast colours and are completely suitable for use in tropical climates.

Normally energized indicating lamps, if employed, shall in general be energized from the station LVAC supply.

Lamps and relays incorporated in alarm facia equipment shall be arranged for normal operation from the station battery, subject to the approval of the Engineer.

Lamp test facilities shall be provided so that all lamps on one panel can be tested simultaneously by operation of a common push-button. Where alarm facias are specified, all alarm and monitoring indications (apart from circuit-breaker and disconnector position indications) shall be incorporated in the facia.

Where specified every circuit breaker panel shall be equipped with one red and one green indicator lamp, indicating respectively circuit closed and circuit open and an amber lamp for indicating 'auto-trip'. Where specified in the lines of mimic diagrams, indicating lamps may be of the three-lamp single-aspect type.

All lamps shall be renewable from the front of panels without the use of special tools.

The variety of indicating lamps provided shall be rationalized to reduce maintenance and spares requirements.

7.6.43.3 Anti-Condensation Heaters

All switchboards, panels, cubicles, motor control centre and the like shall incorporate electric heaters capable of providing movement of sufficient heated air to avoid condensation. The power supply to the heaters shall be manually switched by a two pole switch with red lamp. All heaters on multi-panel equipment shall be controlled from a single point. The related equipment shall be designed to accept the resulting heat input.

Bus wiring shall be incorporated in switchboards for supplying the heaters.

7.6.44 Panel Wiring and Terminal Boards

7.6.44.1 General

All electrical equipment mounted in or on switchgear, panels, kiosks, and desks, etc. shal have readily accessible connections and shall be wired to terminal blocks for the reception of external cabling.

All wiring shall be of adequate cross-sectional area to carry prospective short-circuit currents without risk of damage to conductors, insulation or joints.

All cabling shall be of type CR or CK to BS 6231 unless the design of the plant requires the cabling to withstand more onerous operating conditions in which case cabling shall be suitable

for these conditions. The minimum cross section of wire shall be 2.5 sq.mm. for all secondary wiring associated with current transformers of nominal secondary rating of 0.5 A or greater. The size of wiring for circuits other than CT secondary wiring shall be not less than 1.5 sq.mm. Cross-sectional area, save as permitted in the specification.

The minimum strand diameter of copper or tinned copper flexible conductors shall be 0.20 mm for flexible and the minimum cross-sectional area shall be 0.5 sq.mm. for all cables. For wiring within panels on circuits not directly associated with circuit breaker protection and control, and having a continuous or intermittent, load current of less than 1 amp, the use of smaller line down to 0.25 sq. mm. will be permitted subject to Engineer's Approval.

Where an overall screen is used, this shall be metallic screen or low resistance tape, with drain wire as above.

Wiring shall be supported using an insulated system which allows easy access for fault finding and facilitates the rapid installation of additional cables.

Small wiring passing between compartments which may be separated for transport shall be taken in terminal blocks mounted near the top of each compartment, separately from those for external cable connections.

Both ends of every wire shall be fitted with ferrules of insulating material complying with BS 3858 or equivalent National Standard and engraved in black. The identification numbering system used for the ferrules shall be to the approval of the Engineer. Where new equipment must interface with existing equipment double ferruling shall be employed if the two numbering system are not compatible.

Connections to apparatus mounted on doors, or between points subject to relative movement, shall be made in cable type CK to BS 6231, arranged so that they are subjected to torsion rather than bending.

7.6.44.2 Identification of Cable Cores

Where a wire a multi-core cable passes from one piece of equipment to another, e.g. from a circuit breaker to a remote control panel, the Contractor shall ensure that the identity of the wire is apparent at both ends and intermediate marshalling points by the use of ferrules, which shall permit identification of the cable in accordance with the schematic diagrams. The ferruling system to be adopted shall be a composite marking method to IEC 391 and BS 3858 as appropriate, giving both functional information on the purpose of the individual conductor plus dependant both-end marking.

Should the Contractors normal practice be at variance with the requirements of this Clause he may submit details of the scheme proposed for consideration by the Engineer. The engineer is not obliged to accept the Contractors proposal.

Each core of multi-pair wiring shall be identified by colour and terminal block identification together with an identification tracer per bundle.

Permanent identification of all terminals, wires and terminal blocks shall be provided. Each individual terminal block shall have independent terminals for incoming and outgoing cabling.

7.6.44.3 Terminals and Terminal Boards

Terminal Assemblies shall be of the unit form suitable for mounting on a standard assembly rail, to give the required number of ways. The units shall be spring retained on the assembly fail. Each individual terminal block shall have independent terminals and outgoing cabling.

End barriers or shields shall be provided for open sided patterns.

It shall be possible to replace any unit in an assembly without dismantling adjacent units. Moulding shall be mechanically robust and withstand the maximum possible operating temperatures and torque which may be applied to terminal screw. All live parts shall be recessed in the moulding to prevent accidental contact.

Terminals shall be of the screw clamp type for lower current rating which compress the conductor or termination between two plates by means of a captive terminal screw. Contact pressure of screw clamp terminations shall be independent of each other. For higher current ratings bolted type terminals are permitted. Current carrying parts shall be non-ferrous and plated.

All terminals for 'incoming' cabling shall have testing facilities, which permit the examination of the state of the circuit without disconnecting the associated cabling. Terminal blocks for current transformer secondary shall be fitted with shorting/disconnect facilities.

Terminal blocks for voltage transformers secondaries shall be isolatable.

Terminal blocks in telemetry marshalling cubicles shall be isolatable. The means of isolation shall be fixed and give visual identification of the status of the terminal.

Not more than 1 wire shall be connected to each terminal and cross-connection facilities shall be provided where numerous cores are to connected together.

Each terminal block, and every individual terminal shall be identified. The terminal identification number shall be included on associated schematic and wiring diagrams.

The mounting rail may only be used to provide an earth connection, when firmly bonded to the earth bar and to be approved by the Employer.

The Contractor shall submit samples of the terminal blocks/mounting rail assemblies together with details of his proposed cabling/termination system to the Engineer for approval.

Adjacent terminals to which wires of different voltage, polarity or phase are connected shall be separated by a protruding insulating barrier; this requirement also applies to terminals carrying wires of the same voltage but originating from different sources.

Wires shall be grounded on the terminal boards according to their functions. Terminal blocks for connections exceeding 110V shall be fitted with insulting covers.

Terminal blocks shall be mounted not less than 150 mm from the gland plates, and spaced not less than 100 mm apart, on the side of the enclosure.

Sufficient terminals shall be provided to permit all cores on multicore cables to be terminated. Terminals for spare cores shall be numbered and be located at such position as will provide the maximum length of spare core. At least 10% spare terminals shall be provided in all cases.

The tails of multi-core cables shall be bound and routed so that each tail may be traced without difficulty to its associated cable. All spare cores shall be made off to terminals.

When two lengths of screened cable are to be connected at a terminal block (i.e. junction box) a separate terminal shall be provided to maintain screen continuity.

Should the terminal block manufacturer recommend that specific types of terminal tools are used (eg parallel sided screw/drivers) the Contractor shall provide three sets of these at each sub-station site. In addition the Contractor shall provide 8 numbers, test leads of minimum 1500 mm length which can be inserted into the test terminals of the terminal blocks, at each

sub-station. The test leads shall be capable of being 'jumpered' together for multi-instrument use.

The use of pre-formed factory tested cable connections to field mounted marshalling boxes shall be to the Engineer's approval.

7.6.45 Cable Boxes and Glands

Electrical equipment supplied under this Contract shall be fitted with all necessary cable boxes and glands which shall be complete with all required fittings. Boxes shall be of adequate proportions to accommodate all cable fittings, including stress cones or other means of cable insulation grading, and designed in such a manner that they can be opened for inspection where appropriate without disturbing the gland plate of incoming cable.

Glands for termination of cables to outdoor equipment or indoor areas liable to water spray, hosing or flooding shall incorporate provision for sealing against ingress of moisture or dust, and shall comply with the requirements of BS 6121 for sealing.

Removable gasketted steel gland plates shall be provided for multi-core cables and shall be supported from the sides of the enclosures, as near to the floor or roof as possible while allowing adequate space both above and below the plate for manipulation of the cable and gland. Gland plates for marshalling boxes shall be in the form of removable gasketted steel plate, forming part of the underside of the box.

The terminals for 3 phase cables shall be clearly marked with the phase colours (approved designations) to enable the cables to be terminated in the correct sequence.

Filling and venting plugs where required, shall be positioned so as to avoid the possibility of air being trapped internally and adequate arrangements shall be made for expansion of compound etc. There shall be no possibility of oil entering the cable box from an associated oil filled compartment. Cable sealing ends, shall be arranged to project at least 25mm above the gland plate to avoid moisture collecting in the crutch.

Any chamber which is to be compound filled, shall be clean and dry and at such a temperature before filling that the compound does not solidify during the filling process. Filling orifices shall be sufficiently large to permit easy and rapid filling.

All cable boxes shall be designed to withstand the high voltage d.c. cable tests prescribed in BS 6346, BS 6480 and IEC 55 as appropriate.

Cable boxes for paper-insulated cables shall be complete with universal tapered brass glands (insulated from the box in an approved manner and including an island layer for testing purposes.

Even single core cables are used, particularly for currents in excess of 500 A or as design, adequate steps must be taken to minimize the effects of eddy currents in the gland and bushing-mounted plate.

Cable glands for extruded solid dielectric insulated cables (PVC, EPR, and XLPE) shall be of the compression type and as specified in BS 6121.

Approved glands shall be used on MICC cables

Glands for armored or screened cables above 240 sq.mm. shall be provided with an integral heavy duty earthing lug capable of carrying the full earth fault current for a period not less than 1 second without deterioration.

Cable lugs and terminations for the receipt of all power control and instrumentation cable cores shall be provided.

Cable boxes for the termination of elastomeric cables up in 33 kV nominal service voltage shall be designed and dimensioned to provide adequate insulation in air for cables. Clearance and creepage distances shall be adequate to withstand the specified alternating current voltages and impulse voltages for service under the prevailing site conditions. The performance is to be met without the use of insulating 'boots' shrouds or any other material fitted over or between the cable terminations apart from permanently fitted barriers forming part of the switchgear or cable box.

Means shall be provided for preventing accumulation of dirt, dust, moisture, vermin or insects such as to maintain the anticipated life of the equipment. The Contractor shall ascertain the means by which elastomeric cables are to be terminated and shall provide such information or instructions as necessary to any other contractor or sub-contract or to ensure compliance with this Clause.

The cable crutch within a cable box or equipment panel shall be protected by the use of a heat-shrink plastic 'udder' places over the conductors and crutch.

7.6.46 Joints and Gaskets

All joint faces are to be flat and parallel to the approval of the Engineer and arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil-resisting synthetic rubber gaskets are not permissible, unless the degree of compression is accurately controlled. For gaskets of cork or similar, oil resisting synthetic rubber may be used as a bonding medium.

7.6.47 Junction, Termination Marshalling Boxes, Operating Cubicles etc.

- All junctions, termination and marshalling boxes shall be of substantial sheet steel construction, having enclosure classification and fitted with external fixing lugs and finished in accordance with this Specification for cleaning, painting and finishing.
- The boxes shall allow ample room for wiring, with particular regard to the deployment of wires from the point of entry.
- Outdoor boxes shall have internal anti-condensation heaters and stay bars fitted to doors. Indoor boxes shall be designed such that any condensed water cannot affect the insulation of the terminal boards or cables. No cables shall be terminated into the top of outdoor boxes unless specifically approved by the Engineer.
- Each box shall be complete with suitably inscribed identification labels.
- Any outdoor boxes, cubicles etc containing instruments or meters shall have glazing suitable to permit the visual examination of these.
- Covers shall be arranged for padlocking and padlocks with keys shall be supplied. Cast iron boxes shall have bolted lids requiring the use of special keys or spanners for removal.
- All boxes shall be provided with adequate earthing bars and terminals.
- Notwithstanding information supplied by the Engineer, the Contractor shall, as each box is completed or at intervals as requested by the Engineer, supply to the Engineer copies of accurate termination or destination charts showing the as-fitted arrangement of cables and cores in each box. The Contractor shall, following the Engineer's approval, fit one plastic laminated copy of the appropriate chart to the interior of each box.

7.6.48 Conduit and Accessories

- Conduit, accessories and trunking installation shall comply with the latest issue of the Institution of Electrical Engineers Regulations for the Electrical Equipment of Buildings, unless otherwise approved by the Engineer. In addition installation shall also comply with all local electricity regulations.
- Unless otherwise approved, all conduit and conduit fittings shall be galvanized, of heavy gauge steel, screwed, solid drawn or weld type complying with IEC 423 and IEC 614.
- No conduit smaller than 19mm outside diameter shall be used.
- Standard circular boxes or machined face heavy-duty steel adaptable boxes with machined heavy type lids shall be used throughout. For outdoor mounting all boxes shall be galvanized, weatherproof and fitted with external fixing lugs.
- Conduit terminations shall be fitted with brass bushes.
- The use of running threads, solid elbows and solid tees will not be permitted.
- Conduit ends shall be carefully reamed to remove burrs. Draw-in boxes shall be provided at intervals not exceeding 10m in straight-through runs.
- Conduit runs shall be in either the vertical or horizontal direction unless otherwise approved and shall be arranged to minimize accumulation of moisture. Provision for drainage shall be made at the lowest points of each run.
- Conduits shall be supported on heavy galvanized spacer saddles so as to stand off at least 6 mm from the fixing surface.
- Provision shall be made for the support of internal conductors in instances where the length of the vertical run exceeds 5m.
- All conduits run in any circuit are to be completed before any cables are pulled in.
- Flexible metallic conduit shall be used where relative movement is required between the conduit and connected apparatus, and a separate copper connection provided to maintain earth continuity.
- The maximum number of cables in any conduit shall be in accordance with the latest issue of the IEE Regulations for the Electrical Equipment of Buildings.

7.6.49 Trunking

Steel trunking etc. may be used for running numbers of insulated cables or wires in certain positions to the approval of the Engineer. The trunking thickness shall not be less than 1.2 mm.

7.6.50 Push-Buttons and Separately Mounted Push-Button Stations.

- Push-buttons shall be shrouded or well recessed in their housings in such a way as to minimize the risk of inadvertent operation.
- The colour of push-buttons shall be black unless otherwise required by the Engineer.
- Push-button stations supplied as loose equipment shall be of the metal clad weatherproof type suitable for wall or bracket mounting.
- Each push-button station shall be clearly labeled showing the duty or drive to which it is applicable.

7.6.51 Standards

In the technical specification reference have been made to various clauses of IEC; BS; ISO and ASTM standards. Where any standard referred to in this specification has been superseded by a new standard the reference shall be deemed to be to such superseding standards. Notwithstanding the standard numbers mentioned in the technical specification the Bidders are directed to apply the latest published editions of these standards.

Deviations from the specified standards referred to above shall be given in the Schedule of Proposed Standards at section –7 and shall have to be accepted by the Engineer before contract placement.

7.6.52 Nominal Safety Clearance

Nominal voltages between phases (mm)	33 kV
Minimum clearance between live Part and earth (mm)	381
Minimum clearance between live Fixed metal of different phases (mm)	432
Minimum total air gap between Terminal of the same pole of Disconnectors (mm)	432
Minimum safety clearance between Live metal and positions to which Access is permissible with other Equipment alive (mm)	274(
Clearance from ground to nearest Part not at earth potential of an Insulator supporting live Conductor (mm)	244(

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