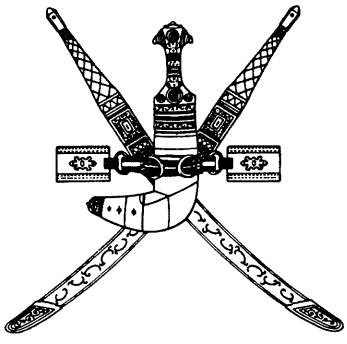
SULTANATE OF OMAN

MINISTRY OF ELECTRICITY AND WATER



STANDARD - OES 27
VOLUME - 2

132/33KV SUBSTATION
2X63MVA 132/33KV SUBSTATION
WITH 132KV OUTDOOR,
SF6 SWITCHGEAR

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132/33KV SUBSTATION

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1.1 SCOPE

The specification covers complete supply, erection and commissioning of all Electrical and Mechanical Plant and Equipment for a typical 132/33KV Substation.

The scope of work shall include the complete design, construction, manufacture, shop testing, packing and marking, shipment, insurance, delivery to site, loading and unloading, complete erection, start-up, commissioning, initial operation, trial run, acceptance testing, putting into commercial operation including construction services during the guarantee period until final acceptance of the complete plant and equipment.

1.2 MAJOR EQUIPMENT

The 132/33KV substation is composed of double open type 132KV bus bars four feeder bays, two transformer bays, one bus coupler and one bus section all equipped as shown on the layout Drawing No. 132KV/ 63MVA/1.

a) Lattice steel structures to support or terminate flexible conductors through strings of insulators or for support of tubular bus bars or any other equipment shall be provided to suit the requirement.

b) The 132KV, bus bars of tubular copper are rated at 31.5KA for 3 sec. and 2000A continuous current at an ambient temp. 50 Deg. C.

c) The 132KV, outdoor, SF6 insulated circuit breakers rating is as follows:

- One bus coupler C.B. rated 40KA, 2500A.
- One bus section C.B. rated 40KA, 2500A.
- Four feeders C.B. rated at 31.5KA, 2000A.
- Two transformer C.B. rated at 31.5KA, 2000A.

d) Isolators are rated as follows:

- Four Nos. for the bus section and bus coupler at 40KA 2500A.
- Two Nos. for each feeder and transformer rated at 31.5 KA, 2000A.

e) 2 Nos. 63MVA, 132/33KV transformers, Vector group Ynd 5 with associated earthing transformers and 33KV neutral earthing resistor. Earthing transformers to include secondary 415/240V winding for substation auxiliaries.

f) 33KV metal clad indoor switchgear comprising 13 panels.

g) Power line carrier equipment including tele-protection and communications equipment suitable for connection with front end computer through R.T.U.

Supply and installation of separate floor mounting marshalling cabinet for interfacing with future remote supervisory control system.

The substation layout including the major equipment is as shown on Drawing No. 132KV/33 63MVA/ 1.

The substation shall be complete with control and relay equipment, alarm facilities, auxiliary DC supplies with batteries and chargers, auxiliary LV switchboards, small power and lighting, fire fighting equipment, earthing and all necessary equipment for the safe and efficient running of the substation.

No central supervisory control scheme is included, provision shall however, be made for the supply of separate floor mounting cabinets and all wiring from the switchgear, control and relay panels to these cabinets for all connections to the remote control and supervisory equipment.

This contract shall, therefore, include all local/remote/supervisory selector switches, auxiliary contact on circuit breakers, isolators etc. for position indication, additional contacts on protection, tripping and alarm relays etc. necessary for a central supervisory control system.

1.3 BUILDING AND FOUNDATIONS

All foundations, walls, roof coverings, concrete floor fittings, ducts and pipe work embedded in the foundations, trenches with floor plates for cables etc. shall be provided.

1.4 All plant, equipment and materials shall conform to the Ministry's Standard OES-11 : General Specifications for Electrical Materials and Equipment.

2.0 132KV OUTDOOR EQUIPMENT

2.1 GENERAL

The outdoor equipment shall be suitable for operation on a 3 phase, 50 Hz system of 132KV nominal voltage with the neutral multiple earthed. The system highest voltage will be 10 percent in excess of the nominal voltage.

The design symmetrical 3 phase short circuit rating shall be 31.5KA R.M.S. at 145KV and all current carrying equipment shall be capable of withstanding this current for a period of three seconds. The bus coupler and bus section and their associated bus bar isolators shall be rated for 40KA.

The withstand impulse levels of equipment shall not be lower than the following when tested in accordance with IEC recommendations.

132KV equipment – 650KV clearances between live metal work and earth shall be not less than those in the appropriate sections of IEC 56 or BS 5227 or the clearances and dimensions given in this specifications and attached drawings whichever is the greater.

Clearances between live metal to earth shall not be less than values given below:

a) Minimum clearance between live metal and earth (mm) – 1300

b) Minimum clearance between live of different phases (mm) – 1500

c) Minimum safety clearance between ground and the nearest point not at earth potential of an insulator (mm) - 2400

d) Minimum safety clearance to nearest live unscreened conductor (BS 162 section clearance to enable normal operation and maintenance work to be carried out (mm) 3500

Creepage distances shall be not less than 45mm per KV of rated system voltage.

2.2 LINE CONNECTIONS

The 132KV overhead line electrical connections shall be of copper and shall be in accordance with BS 125, 159 and 1977 in respect of current rating and material analysis.

Conductors shall be in continuous lengths between supports. Connectors shall be of approved bolted clamps type.

Conductors and connections shall be so arranged and supported that under no circumstances including short circuit conditions, can the clearances between live metal and earth or earthed metal work or between other conductors be less than the specified distances.

Conductors shall consist of either stranded copper wire or tubes. Stranded copper having hollow cores shall be stranded around non-ferrous metal spacers of approved type. The number and diameters of the individual wires forming the finished conductor and the thickness of the tubes shall be subject to approval.

Where dissimilar metals are in contact, approved means shall be provided to prevent electrochemical corrosions. All copper and coppr alloy fittings shall be tin coated.

Hollow stranded copper conductors shall be supported against crushing at clamping positions by sweating solid or plugging.

2.3 INSULATORS

Insulators shall satisfactorily withstand the site climatic and service conditions.

Experience has shown that under the conditions prevailing in Oman, the combination of severe dust pollution and heavy condensation causes flash-overs on insulators and bushings.

132 KV insulators parameters	
Minimum distance between sheds	○ 50 mm
Ratio (spacing/shed overhang)	○ 0.8
Ratio (creepage/clearance)	■ 5
Alternating shed overhang	○ 25 mm
Inclination of top shed (degrees)	○ 5
Arcing distance	○ 1450 mm
Creepage factor	■ 4
Profile factor	○ 0.7

Adjustable arcing horns are required on substation insulators.

Porcelain insulators shall be in accordance with IEC 137 and 273 where applicable. Porcelain shall be should, free from defects and thoroughly verified and the glaze shall not be depended upon for insulation.

Glaze shall be smooth, hard, of a uniform shade of brown and shall completely cover all exposed parts of the insulators. Outdoor insulator fittings shall remain unaffected by atmospheric conditions producing weathering, acids, alkalis, dust and rapid changes in temperatures that may be experienced under working conditions.

The insulators shall be station post type or long rod type with aerofoil self cleaning open profile.

Porcelain insulators shall be secured in an approved manner, preferably by means of bolts or metal clamping plates with suitable packing material inter-posed.

Retaining pins or locking devices for insulating units shall be of phosphor bronze or other approved material, and shall effectively prevent accidental separation of the units.

Creepage distance shall not be less than 45 mm per KV of rated system voltage.

2.4 SURGE ARRESTERS

Surge arresters shall be of the gapless zinc oxide type. Arresters shall be housed in porcelain containers sealed against the entry of moisture and oxygen. Internal components shall be designed to minimise internal corona and also to ensure minimal capacitive coupling with any conducting layer of pollutant on the outside of the porcelain housing.

The surge arrestors shall be of the long duration discharge class (3) and of minimum energy absorption capacity of 2.5 KJ/KV rating.

The porcelain containers shall have open aerofoil self cleaning with minimum creepage of 45mm per KV of system voltage.

Arresters shall comply in all respects with IEC 99-1 or BS 2914:1972, shall be entirely suitable for operation under all system conditions including system voltage rises on unloading long transmission lines and shall have sufficient capacity to discharge the system charging current without damage.

The internal componants of arresters shall be arranged to minimise radial voltage stresses, internal corona and to ensure minimal capacitive coupling with any conducting layer of pollutant on the outside of the porcelain housing.

Surge arrester shall be fitted with a pressure relief diaphragm which shall prevent explosive shattering of the porcelain housing in the event of an arrester failure and the arrester shall have been tested according to high and low current tests specified in IEC 99-1. The surge arrester shall also be fitted with a surge counter.

The standard nominal discharge current shall be 10,000 Amps. Rated voltage is to be 120KV for 132KV heavy duty.

2.5 132KV ISOLATORS (DISCONNECTORS AND EARTHING SWITCHES)

2.5.1 General

The isolating switches shall be of the single throw double air break, center rotating post type or double rotating post, center break type complying with BS 5253/IEC 129. The isolators shall comply with the following system parameters:

Nominal voltage	: 132KV RMS
Frequency	: 50 Hz
Highest voltage	: 145KV RMS
3 Ph. symmetrical short circuit current	: 31.5KA RMS
3 Ph. symmetrical peak withstand current	: 100KA peak
Rating of isolator	: (1250 or 2500 A)
Lightning impulse withstand 1.2/50us to earth	: 650KV peak
Lightning impulse withstand 1.2/50us across open isolator	: 750KV peak
Insulator creepage distance	: 45mm/KV
Clearance rigid conductor to earth	: 1300mm
Clearance rigid conductor to rigid conductor	: 1500mm

Isolating switches shall be designed for live operation and will not be required to break current other than the charging current of open bus bars and connections or load currents shared by parallel circuits or bus bars.

The isolating switches shall have simultaneous group operation of the three (3) poles, the operating mechanism being of the motorised and manual torsional bar type, with earthing blades.

All contact surfaces of the isolating switches, including the earthing blades, shall be covered with a thick silver covering, or must have solid silver insert. The main contact shall be self aligning and so arranged that current flow is through the main contact and not through contact spring devices.

Rotating mechanisms shall be easily lubricated.

The isolating switches and earthing blades shall be designed in such a way that the minimum distances between any live part and the adjacent earthed parts are greater than the dry arc distance of the corresponding insulators.

Isolating devices complete with supporting steel work shall be provided and installed to permit maintenance of any section of the substation plant when the remainder is alive and shall be so located that the minimum safety clearances stated in IEC 45 and BS 162 are always maintained.

The isolating switches and earthing blades shall have a sufficiently high contact pressure to ensure optimum contact and minimum contact resistance for the specified rated operating and short circuit current conditions.

The design of the contacts shall ensure that during the specified short circuit conditions, the contact pressure increases, and the moving blade is held positively in position.

In making, the blades shall have a self cleaning action. Phase markers shall be provided.

Each isolating switch shall be supplied complete with the following:

- The required number of power terminals, made of cadmium bronze, for all power connections.
- A suitable clamp or terminal for earthing each isolator base.
- A suitable clamp or terminal for earthing the operating mechanism and control cabinet.
- Earthing blade flexible earthing connectors.
- The operating mechanism supporting steel structure which shall be dimensioned to maintain a maximum vertical clearance from the top of the concrete foundation to the line terminals.
- Adjustable arcing horns where specified.
- Padlocking facility to enable the isolating switches and earthing blades to be locked in the ''open'' or ''closed'' position, and a position indicator.
- All insulators, contacts and grading rings required.

- All additional supporting steel to carry the fittings for the operating mechanism including all erection and site connection bolts with nuts and lock washers as required.

- A rating plate.

2.5.2 Operating Mechanism

The isolating switch control circuits shall operate at the specified voltage.

The supply to the drive motor shall be 110V DC.

2.5.3 Control Cabinet

The controls and accessories for the isolating switches shall be mounted in a local operation and control cabinet containing as a minimum the following items:

- (10) normally open (NO) and (10) normally closed (NC) voltage free contactsd in addition to those required for motor control and interlocking. The auxiliary contact rated carrying current shall not less than 10 Amps.

- Disconnection, transfer and protection systems for the control and power circuits.

- A heater to prevent condensation of moisture inside the cabinet. The heating system shall be provided with a differential thermostat to maintain a temperature of + 10 Deg. C. above the ambinet temperature.

- A changeover switch for selecting local or remote control.

All the required gland plates and glands for the control cables.

The control cabinet shall be completely factory wired and ready for external connections. Wiring shall be carried out in PVC insulated single core cable to BS 6231, 600/1000 voltage grade, with the copper conductor having a minimum cross section of 2.5 sq.mm. Both ends of all wires shall be fitted with identification ferrules. These wire numbers shall be shown on the assembly wiring and circuit diagrams.

2.6 EARTHING SWITCHES

Earthing switches shall be three pole, simultaneously group operated and manually actuated, and their rated current shall be the same as the main disconnector switches.

A mechanical interlock closure whilst the principal isolating switches are in the closed position shall be included and an auxiliary switch having a minimum of four spare contacts shall be provided.

2.7 OPERATING AND INTERLOCKING

The operating linkage shall be designed to secure the disconnector and earthing blades in the open and closed positions by an ''over-toggle" arrangement with suitable and stops.

Mechanical interlocking between associated disconnector and earthing switch shall be provided in the manual drive and in the electrical interlocking in the motor drive to prevent:

a) Operation of the disconnector when the earthing switch is closed; and
b) Operation of the earthing switch when the disconnector is closed.

When manual operation is required, insertion of the manual operating handle shall isolate the D.C. supply to the motor.

Provision shall be made for pad locking both the disconnector and the earthing switch mechanisms in the open and closed positions.

3.0 132KV, SF6 INSULATED BREAKERS

3.1 GENERAL

The 132KV circuit breakers shall be outdoor, sulphur hexafloride insulated (SF6), single pressure ''puffer" type, with individual self contained springs and pneumatically or pneumo-hydraulically operated. They shall generally conform to the latest edition of IEC 56 and shall be designed to meet the system requirements as stated in this specification. The circuit breaker shall be suitable for mounting directly on concrete pads and supplied with all the necessary galvanised support steel work. The minimum height from ground level to the bottom of live bushing shall not be less than 2500mm.

Where the distance from the ground level to the bottom of the live bushing is less than 2500mm, screened enclosures shall be provided to our approval.

To facilitate transport, lifting lugs, jacking pads or other handling devices capable of supporting each unit when fully erected and ready for service shall be provided. The minimum height of jacking pads above the base shall be 305mm.

The circuit breaker mechanical ON/OFF indicator and the SF6 gas temperature compensated pressure (density) gauge shall be easily read from ground level.

The SF6 gas insulated circuit breaker shall have a filling/monitoring point in the gas system accessible from ground level.

Means shall be provided to allow easy access for the inspection and maintenance of fixed and moving contacts and other enclosed components.

3.2 DESIGN

The 132KV circuit breakers shall comply with the requirements of IEC 56 and shall be covered by test certificates issued by a recognized testing station.

The 132KV feeder circuit breakers shall be suitable for 3 pole single shot time delayed reclosure.

Circuit breakers must be capable of coping with the interrupting duties produced by out of synchronism conditions associated with auto-reclosures, the switching of transformers magnetizing currents, line charging currents, cable charging currents, capacitor banks and short line faults. The circuit breakers shall be re-strike free at 25% of full short circuit currents. Test certificates demonstrating the ability of the circuit breakers for the above duties shall be submitted.

Circuit breakers shall have operated satisfactorily at least not less than 5 years under climatic conditions similar to Oman.

3.3 RATING

The rated normal current based on 50 Deg. C ambient shall be:

a) 2000A for feeder and transformer
b) 2500A for bus section and bus coupler

The rated 3 phase symmetrical short circuit shall be:

a) 31.5KA for 3 sec. for feeder and transformer
b) 40KA for 3 sec for bus section and bus coupler

The rated three phase symmetrical short circuit making current shall be 100KA (peak).

The first pole to clear factor shall be 1.5.

3.4 CONTACTS, ARCING CHAMBERS AND INSULATION

Separate arcing contacts shall be provided on circuit breakers to protect the main contacts from burning during operation and shall be arranged to ensure arcing after commutation of the main current always occurs in the arcing zone between the arcing contacts.

Designs shall permit rapid removal of complete interrupting chambers of SF6 circuit breakers. The drive to the individual main contacts shall be adjustable to ensure simultaneous opening and closing of the main contracts and to compensate for wear in service.

Static and moving seals shall be designed to prevent any leakage of gas or ingress of moisture whilst in service and without deterioration.

Pressure sensitive devices to prevent switching at SF6 gs, pneumatic or hydraulic operating pressures outside the declared limits of operation shall be included.

Where single rods or tubes are utilized for operating the moving contacts of circuit breakers, they shall be securely pinned at each end to prevent rotation or displacement of the contacts. Tubes shall be plugged in an approved manner where contacts or other parts are fixed to the tubes.

Circuit breakers of the SF6 type shall not comprise materials liable to deterioration or create undesirable chemical action when in contact with SF6 under service conditions. Precautions to minimise the presence of moisture and other by products of arcing in SF6 design shall be incorporated.

The SF6 gas for insulation and arc guenching shall conform to the latest editions of IEC 376 and 480 ''Specifications and Acceptance of New Sulphur Hexafloride", and ''Guide to the checking of SF6 gas", respectively.

The auxiliary contacts shall be positively operated by mechanical linkage to the drive to the main contacts. 12 normally open (N.O.) and 12 normally closed (N.C.) voltage free contacts shall be provided. These shall be in addition to those required for mechanical control and indication. The auxiliary contact rated carrying current shall be not less than 10 Amp.

Noise made by the circuit breaker when operating under all specified conditions shall not be such as to cause a nuisance to residents beyond a radius of 100m.

3.5 OPERATING MECHANISMS

Circuit breaker mechanisms shall be so designed that the circuit breaker is free to open immediately the tripping circuit is energized and without he use of any additional external power. Mechanisms shall be "trip free" as defined in IEC Publication 56-1. It is recognized that it may be necessary for contacts to close momentarily prior to operation to ensure satisfactory current interruption.

Two trip coils shall be provided for higher reliability.

The trip coils shall have sufficient continuous rating to cater for the trip coil supervision relay current.

Electrically operated opening and closing device should be designed for 110 V DC operation. The closing coil shall be operable safely between 110% and 80% of rated control voltage. The trip coils shall operate safely at 60% of rated control voltage.

Each part of the operating mechanisms shall be of substantial construction utilizing such materials as stainless steel, brass or gunmetal where necessary to prevent sticking due to rust or corrosion. The overall designs shall be such as to reduce mechanical shock to a minimum and shall prevent in-advertent operation due to fault current stresses, vibration or other causes.

An approved mechanically operated indicator shall be provided on each circuit breaker operating mechanism to show whether the circuit breaker is open or closed and this shall be visible to the operator through a glass window.

A mechanically operated re-settable operations counter shall be fitted.

Where circuit breakers comprise three independent units it shall be possible to make independent adjustments to each unit and except when required for single phase high speed reclosure, the three units shall make and break the circuits simultaneously. In the event of any phase failing to complete a closing operation, provision shall be made for automatic tripping of all three phases of the ciruit breaker.

In the event of the mechanism failing to latch in the closed position the circuit breaker shall be arranged to open at normal speed.

Power closing mechanisms shall be recharged automatically for further operation as soon as the circuit breaker has completed the closing operation and the design of the closing mechanisms shall be such that the circuit breaker cannot be operated inadvertently due to external shock forces resulting from short circuits, circuit breaker operation or any other cause.

Circuit breaker operating mechanisms capable of storing energy for at least two complete closing and tripping operations local to the equipment and without recharging, are preferred. Mechanisms incapable of storing energy for at least two complete operations shall utilize the substation 110V D.C. supply for recharging the mechanism; other mechanisms shall preferably utilize the LV A.C. supplies for recharging duties.

Pneumatically operated mechanisms shall be provided with an air receiver of sufficient capacity for at least two complete closing and tripping operations without recharging and located locally to each 3 phase circuit breaker.

Hydraulically operated mechanisms which inorporate gas filled accumulators shall be capable of storing their compressed gas with minimal leakage for the expected life of the equipment without recharging. Evidence of satisfactory service experience with the design to be used is to be submitted. The design to be used shall have satisfactory service experience.

If a circuit breaker closing mechanism is not fully recharged for further operation within a predetermined time after a closing cycle, the mechanism shall be locked out and an alarm initiated, similarly pneumatically operated circuit breaker tripping mechanisms shall be prevented from operating and an alarm shall be initiated if insufficient air pressure is available. Anti pumping action shall be incorporated in the mechanism control circuit.

Where possible, circuit breakers shall be provided with slow acting manually powered operating devices for inspection and maintenance purposes only. It shall not be possible to slow close a circuit breaker when in normal service position.

3.6 LOCAL CONTROL CUBICLES

Circuit breaker operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof and weather proof cubicles. Where appropriate for 132KV breakers, the cubicles shall be preferably free standing, with front and rear access.

Cubicles shall be of rigid construction preferably folded but alternatively formed on a framework of standard rolled steel sections and shall include any supporting steel work necessary for mounting on the circuit breaker or on concrete foundations. Access to all compartments shall be provided by either removable panels or doors with lift off hinges. Bolts or carriage keys shall not be used to secure the panels or doors. All fasterings shall be integral with the panels or doors, and provisions made for locking.

Doors and panels shall be rigid and fitted with weather proof sealing material. The operating mechanism/control cubicles shall conform to I.P. 54 as defined in IEC 529.

Cubicles shall be well ventilated through vermin proof louvers comprising a brass gauze screen attached to a frame and secured to the inside of the cubicle. Divisions between compartments within the cubicle shall be perforated to assist air circulation. In addition, an anti condensation heater of an approved type shall be provided and controlled by a single pole switch and thermostat mounted within the cubicle.

Access doors or panels shall be glazed where necessary to enable instruments to be viewed without opening the cubicle. The arrangement of equipment within the kiosk shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus.

Circuit breaker control position selector and circuit breaker operating control switches shall be installed in the cubicle. Circuit breakers control from this position will be used under maintenance and emergency conditions only.

Approved schematic diagram of the part of the control system local to the circuit breaker, identifying the various components within the cubicle and on the circuit breaker and referring to the appropriate drawings and maintenance instructions, shall be affixed to the inside of the cubicle access door. The diagram shall be marked on durable non fading material suitable for the specified site conditions.

All incoming auxiliary supply cables shall be terminated directly into switch fuse isolators without intermediate terminals and provision shall be made for looping these supplies into similar cubicles in the same substation site.

The circuit title shall be prominently displayed on a permanent label mounted on the outside of the cubicle. Labels shall be interchangeable.

Each cubicle shall be fitted with a telephone socket outlet. All sockets are to be wired to a common circuit and connected to similar sockets in all relay and control panels.

Where cubicle design permits, the necessary terminal blocks, cable glands etc. shall be provided for the marshalling of all ancillary equipment cabling associated with the circuit i.e. bus bar selector and line isolating switches, current and voltage transformers etc., to be routed to remote control and relay panels. Alternatively a separate marshalling cubicle or kiosk shall be provided.

The switchgear shall be equipped with a SF6 gas supervisory and safety devices which shall meet the following requirements.

a) Each sealed gas compartment shall be equipped with a gas filling nipple.

b) A gas densimeter with a provision for two settings shall be mounted on each sealed gas compartment. The first setting shall initiate an alarm that a SF6 top up is required, when the density has fallen below 95% of rated ensity.

c) Further, SF6 refilling equipment, to supplement the loss of gas due to leakages, shal lbe supplied as a part of switchgear. The refilling equipment shall consist of an SF6 cylinder, densimeter testing equipment and a refilling device, all mounted on a moveable cart.

3.7 CURRENT TRANSFORMERS

The current transformers shall be, outdoor, free standing and complying in general to BS 3938, IEC 185. C.T.'s shall have two wound primary windings and three secondary windings housed in porcelain insulators, filled with pure mineral oil to IEC 296 and hermatically sealed. The windings shall be designed for a constant 50% over load.

The insulator units shall be made of commercial grade, wet process porcelain, with aerodynamically shaped sheds and shall be designed to withstand the static and dynamic stresses imposed by rated voltage, short circuit current, conductor pull and/or other loads imposed by service conditions. The creepage distance shall be 45 mm/kv.

C.T.'s shall be subjected to the following routine and type tests:-

Type Tests	**Method**
Short time current	IEC 185 cl. 19
Temperature rise test	IEC 185 cl. 20
Impulse voltage test	IEC 185 cl. 21 IEC 60 : 5 impulses at 650 KV
Accuracy (Metering winding)	IEC 185 cl. 29
Composite error (protection winding)	IEC 185 cl. 39
Artificial pollution test solid layer method	IEC 507 cl. 14.2 and 18.2
Porosity test (insulator)	IEC 233 cl. 8
Temperature cycle test (insulator)	IEC 233 cl. 9
Verification of dimension (insulator)	IEC 233 cl. 7

Routine Test	Method
Verification of terminal markings	IEC 185 cl. 22
Power frequency test on primary	IEC 185 cl. 15 KV A.C. I min
Power frequency test on secondary	IEC 185 cl. 16 A.C. I min
Over voltage inter-turn test	IEC 185 cl. 17
Accuracy	IEC 185 cl. 30
Composite error	IEC 185 cl. 40
Tests on class X core knee point e.m.f.	BS 3938 cl. 4-4-3
Electrical routine tests (insulator)	IEC 233 cl. 5 & 6

Primary winding conductors shall have a short time current rating not less than that of the associated switchgear.

Magnetisation and core loss curves and secondary resistance shall be provided for each type and rating of current transformer.

Current transformers for balanced protective shemes, including neutral current transformers where appropriate, shall have matched turns, ratios, and shall have magnetisation characteristics to meet the circuit requirements fully.

Current transformers provided for protective gear purposes shall have overcurrent and saturation factors not less than those corresponding to the design short circuit level of the system. The output of each current transformer shall be not less than 15 VA with an accuracy limit factor of 15 and the Contractor shall ensure that the capacity of current transormers provided is adequate for operation of the associated protective devices and instruments.

The secondary windings of each group of current transformers shall be earthed at one point only. The rated secondary current shall be 1A.

The Contractor shall provide details of their method of calculating the outputs of the current transformers for approval before starting manufacture.

3.8 VOLTAGE TRANSFORMERS

132KV voltage transformers shall be of the capacitor type and shall be suitable for connection of telecommunication matching units and for mounting of wave traps for the operation of carrier accelerated tripping, communication and supervisory systems.

Voltage transformers accuracies and outputs shall be in accordance with IEC 186 and shall have a secondary phase to phase voltage of 110 when rated nominal voltage is applied to the primary.

Voltage transformers shall have secondary HRC fuses and links mounted in terminal boxes adjacent to the transformer and these boxes shall be at a height that will permit access to the fuses and links from ground level.

The primary will be connected directly without fuses.

Outdoor voltage transformers shall be provided complete with galvanised steel supporting structures such that the earthed end of the porcelain insulators is not less than 2.5 meters above ground level.

Primary terminals of all outdoor voltage transformers shall be tinned.

3.9 CONTROL UNITS

The control units allocated to each bay shall contain all operating and interlocking controls, the protective circuit breakers for the drives and voltage transformers, indication instruments as well as a sufficient number of connection terminals. Operating controls must be provided for all switching devices and the switch positions shall be exactly represented on a mimic diagram.

The interlock system shall prevent all incorrect operations of the disconnecting and earthing switches and must fulfill the following requirements:

- Operation of the disconnecting switches only under the condition that the circuit breaker is switched off.
- Switching off a circuit breaker only under the condition that the disconnecting switches of the corresponding bay have attained their fully closed position or if they are completely switched off.
- Switching in a circuit disconnecting switch only in the event that the earthing switch is switched off and switching in the earthing switch only in the event that the circuit disconnecting switch is switched off.
- Operation of the bus bar disconnecting switches only under the condition that the associated bus bar earthing switches are switched off and operation of the associated earthing switches only in the event that the bus bar disconnecting switches are switched off.
- Blocking of the second bus bar disconnecting switch in the event that a bus bar disconnecting switch is not fully switched in or switched off.

Furthermore, each bay shall be provided with SF6 maintenance and supervisory equipment for the gas filled chambers, indicating instruments as specified, protective circuit breakers for the protection of the secondary windings of the potential transformrs as well as the switchgear drives and a socket with earth contacts.

Small wirting terminations shall be provided in such numbers that all auxiliary cables which will run from other sections of the station into the bay can be connected, taking into account the connection facilities for the remote control and tele measuring equipment to be added at a later date. Over and above these terminals, facilities shall be provided for the testing of current transformers so that instruments may be disconnected without opening the secondary circuit of the current transformer.

4.0 33KV SWITCHGEAR

The 33KV switchgear offered shall be of the indoor, single bus bar, totally enclosed metal clad type with vertical or horizontal draw out circuit breakers or fixed metal clad SF6 insulated type with vacuum or SF6 circuit breakers for installtion in brick-built substation. The switchgear shall be arranged in the form of a single switchboard and equipped as shown on the attached single line diagram and detailed in the schedule of equipment.

4.1 GENERAL REQUIREMENTS

The switchgear shall be of robust construction and shall be unaffected in part or whole by the forces imposed by short circuit or other fault currents, operation, vibration or temperature changes. The switchboard shall be strictly in accordance with BSS 162/IEC 298 unless otherwise specified herein, and shall be extensible at both ends. Phase rotation and colour markings shall comply with BSS 158.

All instruments, instrument transformers, all components and all materials used in switchgear shall conform to appropriate BSS/IEC. The switchgear shall be designed to facilitate inspection, cleaning, maintenance and repairs. The switchboard shall be dust and vermin proof. The switchboard shall be of compartmental design divided into separate compartments for the circuit breaker, the bus bars and the cable circuit.

The system voltage, rated symmetrical short circuit and impulse level shall be as follows:

Normal system voltage	33 KV
Highest system voltage	36 KV
Symmetrical short circuit current at rated voltage	25 KA
Impulse level	170 KV

The 33KV system neutral shall be resistance earthed. All current carrying parts shall be capable of withstanding the specified short circuit current for three seconds.

4.2 RATING

The normal continuous rating of the switchgear and bus bars in temperature conditions of Oman shall be as specified in Technical Schedules.

All current carrying parts of the switchgear, namely the circuit breakers, bus bar, current transformers, isolating contacts, connections, joints etc. shall be capable of carrying the specified rated current continuously under climatic conditions of Oman. The temperature rise in any part shall comply with BSS 5311 BSS 159 or other relevant BSS taking into account the site ambient temperature. BSS rating along side the Oman rating shall be specified.

4.3 ISOLATION AND INTERLOCKS

The locking arrangement in genral should conform to Oman safety rules books Second Edition – January 1989 or latest. Each switchboard shall be provided with approved means of isolation of circuit breakers and circuits and be complete with automatic shutters to screen off all live parts. The switchgear must be fully interlocked to prevent mal operation. To obviate unauthorized operations, locks each with two keys of approved make shall be included for:

i) Locking out each circuit breaker in the isolated or off position.
ii) Locking movable shutters screening live parts (lock to be coloured red).
iii) Locking circuit breakers control switch.
iv) Locking voltage transformer in the racked in position
v) Locking voltage transformer spout shutter

All locks to differ and have individual keys. Each key is to bear the number of the lock and carry a tag identifying the circuit or plant to be locked. To facilitate phasing out of any incoming circuits against the bus bars, arrangements shall be provided to enable manual opening or closing any of the related shutters independently with the circuit breaker withdrawn and for locking any of these shutters independently in the open or closed position.

4.4 CIRCUIT BREAKER CARRIAGE AND ISOLATING EQUIPMENT

Circuit breaker isolating equipment and wheeled carriage for removal of the circuit breaker shall be an integral part of the circuit breaker. Suitable external guide rails shall be supplied for fixing in the substation in front of the switchgear carriage while inserting or removing from the cubicle.

4.5 INTEGRAL EARTHING

Integral means shall be provided in the switchgear for circuit and bus bar earthing preferably through circuit breaker. The earthing shall be complete with all necessary mechanical interlocks to prevent mal operations.

4.6 EARTHING

Each switchboard shall be provided with a copper earth bar of sectional area not less than 50mm x 6mm. All metal, instrument and relay cases of the panels shall be connected to the earth bar by copper conductors not less than 2.5 sq. mm cross section.

4.7 HEATERS

In view of the high humidity prevailing at the site, each panel shall be provided with suitably rated heater for operation from 240V AC supply as per OES-11 Clause 0.28.

4.8 AUXILIARY SWITCHES

Auxiliary switches shall be provided to interrupt the DC supply tro trip coils immediately after their operation has been completed.

All necessary interphasing/auxiliary switches for control, metering, protection and indication for supervisory control which may be adopted at a future date, shall be provided on each circuit breaker panels plus two spare ways normally close and two spare ways normally open. The auxiliary switches shall be wired to a suitable terminal block on the panel.

4.9 HEALTHY TRIP INDICATION

15 Watt 110V DC lamp with series limiting resistance operated through a spring loaded push button test switch shall be provided on each circuit breaker panel. Alternatively, continuously monitoring scheme with low consumption (less than 5MA) be provided.

4.10 LOCAL/REMOTE SELECTOR SWITCH

A local/remote selector switch to be provided on each circuit breaker panel to facilitate control of the breaker from a remote location.

4.11 TEST TERMINAL BLOCKS

Current transformer secondary wiring shall be connected through terminal blocks with change over links to permit easy ratio change over and testing.

The terminal blocks shall be mounted in front of the panel and suitably insulated and provided with a detachable dust proof cover.

4.12 BUS BARS

The bus bars shall be hard drawn conductivity copper bars, silicon rubber insulated throughout the length.

The bus bars on the switchgear shall be arranged to permit future extensions at each end.

Provision shall be made at the bolted connections for easy accessibility for maintenance and extensions.

Bus bars and connections shall be fully rated braced and supported to withstand the dynamic, thermal, and dielectric stress over the full length of the switchboard.

All bolted connections shall be made with high-tensile strength bolts effectively secured against loosening.

4.13 CIRCUIT BREAKERS

The circuit breakers shall be sulphur hexafloride (SF6) or vacuum type. The breakers shall have a guaranteed ruptering capacity of not less than 1500MVA at 33000 V and must conform to BSS5311/IEC 56 taking into account the climatic conditions of Oman.

Type test certificates for the circuit breakers from an internationally recognized testing authority shall be submitted.

Motor (240 V single phase or 3 phase 415 V 50 Hz) charged spring closing mechansim, which can be recharged after the circuit breaker has closed shall be provided.

Circuit breakers shall be independently secured in position by means of bolts, irrespective of the raising and lowering gear. Except for those joints which have to be broken for maintenance purposes, all other joints shall be machine faced and packing shall be of approved material and thickness.

Circuit breakers and mechanisms shall be capable of a minimum 1000 load operations without major overhauls. Preference will be given to circuit breakers having minimum maintenance during this period.

4.13.1 SPECIAL REQUIREMENTS – SF6 BREAKERS

SF6 enclosures shall be capable of withstanding the maximum pressure that can occur in service without leakage or permanent distortion.

Unless otherwise agreed, gas density and/or pressure indicators shall be provided. Circuit breakers must be suitable for breaking normal loads if the gas is reduced to atmospheric pressure.

If SF6 circuit breakers are sealed for life they shall be guaranteed for a minimum of ten years normal duty. For refillable circuit breakers gas loss shall be less than one percent per annum.

4.13.2 SPECIAL REQUIREMENT – VACUUM BREAKERS

The composition of the contact material and the design of the contact shape shall be such that the switching characteristics do not deteriorate with use.

All vacuum units shall be stored before use before installtion in the circuit breaker for a minimum of 20 days. The vacuum shall be tested before and after storage and no deterioration shall have taken place.

The contractor shall retest the vacuum at site as part of the precommissioning procedures.

The technical submission in respect of vacuum breakers shall include details of precautions taken to prevent X-ray emission.

Details shall be provided of the maximum current chop level.

4.13.3 ISOLATING FEATURES

The following circuit breaker operating locations shall be provided:

a) Maintenance
b) Busbar Earth
c) Service
d) Circuit Earth

Mechanical indication shall be provided to show the location of the circuit breaker. Such indications shall be visible from the front of the equipment at all times.

In each operating location the circuit breaker shall be positively registered in its housing before the circuit breaker closed or opened.

4.13.4 INTERLOCKS

All mechanical interlocks shall be of the preventive type and shall be arranged to prevent mal-operation of the equipment if the interlock is defeated.

Electrical interlocks shall also function so as to prevent the closing operation of the circuit breaker.

Clearly labeled mechanical interlocks shall be provided which are designed to prevent:-

a) A closed circuit breaker from being withdrawn from or inserted into the isolating contacts.

b) Tripping by attempted isolation.

c) The closing of a circuit breaker except when correctly located in the service, earthed or isolated positions.

d) A circuit breaker from being plugged into the isolating contacts if the arc chutes or circuit breaker chambers are not in position.

e) A circuit breaker being closed in the service position when the secondary circuits between the fixed and moving portions are not completed.

4.13.5 CIRCUIT BREAKER OPERATING MECHANISMS

Motor wound spring operating mechanisms shall be such that the closing spring is automatically charged while the circuit breaker is closed.

The operating mechanism shall be designed so that the circuit breaker is free to open immediately once the trip coil is energised. A direct acting mechanical trip via an emergency button shall be provided on each breaker.

Means shall be provided for the manual operation of the circuit breaker for maintenance purposes. Manual slow closing shall be possible in the maintenance position only.

An approved mechanically operated indicator shall be provided to show whether the circuit breaker is open or closed.

In the event of failure to latch in the closed position it shall not be possible for the circuit breaker to open except at normal speed.

Means shall be provided to prevent the local and remote control apparatus from being in operation simultaneously. It shall not be possible, without the use of tools, to gain access to the tripping toggle or any part of the mechanism which would permit defeat of the mechanical tripping feature.

In the service position it shall not be possible to render the electrical tripping feature inoperative by any mechanical locking device. However, a lockable mechanical device shall be provided to render the circuit breaker mechanism inoperative when used in the earth position. For test purposes it shall be possible to complete the closing, tripping an interlock circuits when the circuit breaker is isolated.

4.14 BUS WIRES

The following bus wires of appropriate copper section, in no case less than 2.5 sq. mm PVC insulated in appropriate colour code shall be provided on the switchboard.

- DC trip circuit
- DC closing spring release coil circuit
- Remote group alarm circuit
- Circuit breaker close and open red and green lamp indication circuit (110V DC)
- Circuit breaker panel heater circuit (240V AC)
- DC auto trip amber lamp indication circuit

The bus wires shall be neatly cleated and terminated on both sides of each individual panel on terminal blocks with adequately rated terminal studs complete with all necessary provisions for inter panel connection.

4.15 LABELS AND SECONDARY FUSES

Each panel of the switchboard shall have a blank circuit label approximately 30cm x 8cm mounted on the front of the panel in a prominent position.

These label shall be made of suitable engraving material approximately 2mm thick, white surface with black engraving. Small blank labels of similar material shall be mounted on the rear of the panels. The circuit names shall be engraved at site later. All other labels shall be of similar and engraved in English/Arabic.

All necessary fuses and links shall be supplied and they shall be fitted with clearly legible label indicating the circuit and shall be grouped according to their functions to facilitate identification. Fuse label shall indicate the current rating of the fuses and code symbols shall correspond with the diagrams. All secondary fuses shall be of the cartridge type to BSS 88.

M.C.B.'s in lieu of fuse are acceptable.

4.16 INSTRUMENTS

Dial type, full deflection 270 Deg. 96 x 96mm switchboard pattern, flush mounting type moving iron voltmeters and ammeters shall be provided.

4.17 SMALL WIRING

All wiring shall be 2.5 sq.mm stranded copper conductor, 600V tropical grade PVC insulated. All small wiring shall be suitably terminated and fitted with captive identification ferrules and marked with circuit number. Trip circuit shall have an additional ferrule coloured red and marked "Trip".

Each circuit identification number shall be suffixed with the panel identification letter. All terminal blocks shall be provided with detachable covers. The trip circuit cables shall be coloured black. The current transformer secondary wires shall preferably be coloured with their respective phase colours.

4.18 VOLTAGE TRANSFORMERS

3 Phase voltage transformers shall be as specified in the Details of Equipment and shown on the single line diagram. The voltage transformers shall comply with IEC 186/BS 3941.

Secondary voltage shall be 100/sq. root of 3 and tertiary voltage 110/3. The voltage transformer shall be having a rating of 200VA per phase class B accuracy. Cartridge type secondary fuse or MCB's shall be provided.

4.19 CURRENT TRANSFORMERS

Current transformers shall be cast resin insulated and conform to BS 3938/IEC 185. Current transformers shall be so rated and designed that they shall not sustain any damage due to through fault currents expected on a system fault level of 25 KA. All secondaries shall be one ampere.

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

Design magnetisation curves and D.C. resistance values shall be submitted for approval 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.

4.20 33KV CABLE TERMINATIONS

The cable end terminations shall be suitable for 3 core, 300sqmm, 33KV XLPE insulated cable as specified in the Details of Equipment. The cable terminations shall be of the dry type and shall be complete with gland armour clamps, connecting copper bonding straps, cable lugs and all necessary making of material. Cable terminations shall be separated from all other compartments such as CT chambrs, bus bar compartment etc. A channel iron bracket with cleats shall be provided for cable support.

4.21 TESTS

4.21.1 Type Test

Type test certificate from an internationally recognized authority shall be produced as evidence that the circuit breaker has been successfully tested to BSS 5311/IEC 298 on its own structure, complete with isolating features, with vent outlets forming part of the unit and with the main connections and bus bars. The certificate shall include the test results and details of the circuit breaker performance during the tests.

4.21.2 Temperature Rise Test

Temperature rise test shall be carried out in accordance with BSS on the following panels:

a) One complete feeder panel of the switchboard.
b) One complete bus section panel of the switchbaord.

Certificate of temperature rise test carried out previously on identical panels may be acceptable.

4.21.3 Routine Tests

Routine tests shall be carried out on all items of equipment in accordance with the relevant BSS/IEC.

4.22 ADDITIONAL EQUIPMENT

4.22.1 Testing Plugs

The switchboard shall be provided with one set of 3 phase test plugs fully insulated for test voltage usually applied to switchgear cables. Terminals of the test plugs shall be arranged to receive flexible conductors upto 120sqmm single core normally used for current injection tests.

4.22.2 Tool Cabinet

The switchboard shall be provided with a complete set of tools housed in a floor/wall mounting, sheet metal tool cabinet with double leaf doors fitted with handle, locking bar and with two keys.

4.22.3 Key Board

The switchboard shall be provided with a sheet metal wall mounting key cupboard with a single leaf door fitted with locking bar and lock with two keys.

The interior of the cupboard shall be arranged to store substation keys on brass hooks and shall be clearly labelled. The key cupboard shall include a log book for record of key issues.

4.22.4 Permit to Work Locking Off Boxes

The switchboard shall be provided with two sheet metal, wall mounting boxes, with single leaf doors. The purpose of these boxes is for the storage of switchgear keys together with a copy of the "Permit to Work" form issued for purposes of working on equipment and cables. The box shall be approximately 50cm long horizontally x 30cm wide x 15cm deep and shall be fitted with cylinder type lock with two individual keys. The box shall include six locking off padlocks suitable for bus bars and voltage transformer spout shutters.

These shall not be master keyed but will have two individual keys. The locks shall be coloured "Red" and clearly numbered.

5.0 TRANSFORMERS AND ASSOCIATED EQUIPMENT

5.1 GENERAL REQUIREMENTS

The transformer shall be robust construction and shall be unaffected in part or whole by the forces imposed by short circuit or other fault current, operation, vibration or temperature changes. The transformers shall comply with IEC 76/BSS 171 unless otherwise specified. The transformers shall be of the double would shell or core type, three phase oil immersed, suitable for outdoor installation and operation under the climatic conditions referred to in OES 11.

The transformers shall be suitable for continuous oper'ation on the system as detailed in OES 11.

The design fault levels and impulse withstand levels shall be as specified in OES 11.

Phase to phase and phase to earth clearances shall not be less than the clearances specified in the appropriate sections of BS 5227. The height from ground level to bushing insulator base shall not be less than 2.50m.

The transformrs shall be guaranteed to carry continuously their continuous maximum rating applicable without exceeding the maximum temperature rise specified in Clause 5.2. The transformers shall be provided with the required accessories as specified in the details in equipment.

The transformer shall be suitable for cyclic overloading in accordance with IEC 354.

The auxiliary transformers shall be ONAN. Transformers shall be capable of operating satisfactory in parallel with each other, sharing the load within BS limits.

5.2 63MVA 132/33KV TRANSFORMERS

Two 63MVA 132/33KV power transformers complete with all associated equipment are required to be supplied and installed at the station.

a) **Continuous Maximum Rating**

The transformers shall be capable of carrying their maximum specified load continuously under worst temperature conditions encountered in Oman and at any tapping without the temperature rise of oil in the hottest region exceeding 40 Deg. C as measured by the thermometer and that of winding 50 Deg. C as measured by winding resistance. If any transformer exceeds the above temperature rise limits on test, it may be rejected.

b) **Method of Cooling**

The cooling of the transformers shall be ONAN/ONAF and each transformer shall be capable of operating under ONAN condition upto 75% or more after which the cooling equipment shall come into operation and operate as an ONAF unit.

Transformers shall be capable of remaining at full load for 20 minutes after failure of blowers without the calculated winding hot spot temperature exceeding 140 Deg. C.

c) **Voltage Radio**

The voltage ratio shall be on normal tapping and on load 132/33KV, the higher voltage winding shall have tapping in steps of 1.11% from +5% to -15% (total number of taps 19).

d) **Impedance Voltage and Regulation**

The impedance at normal ratio and M.C.R. (Maximum Continuous Rating) shall be 16%.

e) **Electrical Connections**

The transformers shall be connected in accordance with BSS 171 as follows:

- H.V. Winding – connected in Star
- L.V. Winding – connected in Delta
- Vector Group reference – Ynd5
- The neutral of the 132KV winding shall be brought out through external bushing.

Duty Under Fault Conditions

The transformers shall be capable of withstanding without damage or distress an external fault between phases for three seconds with the voltage on the other side of the transformers maintained at its full normal value.

Evidence shall be submitted with the tender as to the extent to which the manufacturer has proved or is able to prove either by calculation or test the ability of the specified transformers to withstand on any tapping, without damage under service conditions, the mechanical stresses arising under short circuit in accordance with IEC 76.

The tenderer shall state in the Schedule of Particulars a brief description of those transformers or parts thereof which have been subjected to short circuit test or for which short circuit calculations are available. It is preferred that this information relates to designs comparable with the transformers tendered but in the event this is not so the Employer reserves the right to require calculations to prove that the design of transformers tendered will satisfactorily comply with this Clause.

g) **Harmonic Suppression**

Transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third, fifth and seventh harmonic, and to minimise the determental effects resulting therefrom.

h) **Vibration and Noise**

The transformers shall be designed considering that noise generated during the normal operation of the transformer under 100% loaded condition is limited to and shall not exceed 85 dBA when measured at a distance of 300mm from the transformer body all around at a height above ground level corresponding to one half of the height of the tank or at a height of 1.2 metres which ever is less.

The vibration generated due to magnetostriction of core laminations shall be limited to a minimum.

i) **Windings**

132KV star connected windings shall have graded insulation as defined in IEC 76.

All transformers windings for 33KV and below shall have uniform insulation as defined in IEC 76. All neutral points shall be insulated to withstand applied voltage tests in accordance with IEC 76.

The transformers shall be designed to withstand the impulse voltage levels specified in OES 11 and shall withstand the power frequency voltage tests specified in the Schedule of Tests.

The windings shall be located in a manner which will ensure that they remain electrostatically balanced and that their magnetic centers remain coincident under all conditions of operation.

The windings also be thoroughly seasoned during manufacture by the application of axial pressure at a high temperature for such length of time as will ensure that further shrinkage in unlikely to occur in service. Provision shall however be made for taking up any further contraction by means of spring loaded and adjustable clamps or other similar devices. Tenderers shall submit drawings with their offers showing types of windings, methods of bracing and clamping and details of oil cooling ducts and precautions taken to prevent shrinkage of insulating material in service.

The windings and leads of all transformers shall be braced to withstand the shocks which may occur through rough handling and vibration during transport, switching and other transient service conditions.

The design maximum current density in the windings shall not preferably exceed 2.6 amperes per sq. mm at continuous maximum rating of the transformer with normal voltage plus normal frequency. The conductors shall be of high conductivity electrolytic copper.

j) **Magnetic Circuit**

The design of magnetic circuit shall be such that to avoid static discharges, development of short circuit paths internally or to the earthed clamping structure and the production of flux components shall be insulated with a material stable under the action of pressure and hot oil.

The winding structure and major insulation shall be designed to permit unobstructed flow of cooling oil through core cooling ducts to ensure efficient core cooling.

The magnetic circuit shall be insulated from all structural parts and shall be capable of withstanding a test voltage to core bolts and to the frame of 2500 volts RMS for one minute.

k) Flux Density

Cores shall be constructed from cold rolled grain oriented steel sheets.

Design shall be such that there will be no adverse effects due to core or stray flux heating with quality of steel employed and that when operating under most onerous conditions envisaged in IEC 76 and IEC 354 the flux density in any party of the magnetic circuit does not exceed 19,000 lines per square centimeter (i.e. 1.90 tesla).

l) Internal Earthing Arrangements

The following provision shall be made for internal earthing:

i) The main core clamping structure and its clamping bolts, and the coil clamping rings (if at earth potential) shall be bonded together and to the transformer tank by copper strip.

ii) The magnetic circuit shall be electrically bonded to the main clamping structure at one point only by means of a removable link.

The link referred to in l (ii) above shall be located on the same side of the core as the main earth connection, and shall be accessible from the manhole in the tank cover after lowering the oil to the level of the top yoke.

Coil clamping rings at earth potential shall be connected to the adjacent core clamping structure on the same side of the transformer as the main earth.

Earthing connections are to have a cross sectional area of not less than 80 sq. mm.

m) Main Tank

The main tank shall be designed to house the transformer core and winding and arranged to prevent any movement of the core structure inside the tank. Provision shall be made to enable the core to be lifted out with ease for maintenance and inspection.

The tank shall be of mild steel welded construction of adequate dimensions and braced and reinforced as necessary with rolled steel sections to prevent any disrotation due to transportation, lifting, internal pressures and temperature variations.

The top of tank shall have provision to give access to termination of windings and earthing point etc. without completely draining the tank of oil. Suitable lifting lugs designed to carry the whole weight of the transformer, including the fittings and oil, shall be welded to each tank.

Transformer tank shall be flat bottomed, designed and reinforced so that the complete equipment may be skidded in any direction.

The tenderer shall describe the means to be used to protect the tank bottom when in service. The design of the tank, the tank cover, and the under carriage, the radiator tank etc. of the transformer shall be such that:

i) Internally there are no pockets in which oil can remain when draining the tank, or in which air can be trapped when fitting the tank.

ii) Externally there are no pockets in which water can lodge.

iii) It shall be possible to gain easy access to all external surfaces for painting.

Pockets shall be provided on each transformer tank for a stem type thermometer and the bulb of a temperature indicator. These pockets shall be located in the position of maximum oil temperature at continuous maximum rating (C.M.R.) at it shall be possible to remove any bulb without lowering the oil level in the tank. The stem type thermometer pockets shall be provided with captive screw-caps to exclude water and dirt. A flange with captive screw-caps to exclude water and dirt. A flange type air release plug shall be provided at the highest point in each tank covering. The tank shall be designed to withstand when empty a vacuum of 50cm of mercury or the vacuum required during drying out whichever is greater. The minimum plate thickness shall be as follows:

Side plates: 12mm
Bottom plates: 25mm

The whole of the tank and fittings shall be sand blasted inside and outside to remove all scale and rust before painting. The inside of the tank shall be painted with an approved oil resisting varnish.

n) Jacking Lugs

Each transformer shall be provided with atleast four jacking lugs located at the four corners of the transformer tank. The lugs shall be approximately 50cm above the ground level.

o) Conservator

Each transformer shall be provided with an overhead conservator tank formed of substantial steel plates and above the highest point of the oil circulating system. Connections into the main tank shall be at the highest point to prevent the trapping of air or gas under the main tank cover.

The capacity of each conservator tank shall be adequate for the expansion and contraction of oil in the whole system under the specified operation conditions.

Conservator tanks shall also be provided with a cleaning door, filling, cap draining valve with captive cap and oil level gauge at each end which can be easily read from ground level. Temperature range to be expected under Oman conditions in the open is 0 Deg. C to 90 Deg. C.

The pipework between the conservator and the transformer shall comply with the requirements of Clause 5.2(U) and of valve shall be provided at the conservator to cut off the oil supply to the transformer.

p) Valves

Valves shall be of the sluice type, have non-rising spindles and shall be closed turning the hand wheel in a clock wise direction. They shall have machined flanges and provision for locking in the closed and open positions. Details of the locking devices shall be clearly shown on the general arrangement drawing.

Every valve shall be provided with an indicator to show clearly the position of the valve and each hand wheel shall be fitted with a brass name plate with engraved and filled letters or figures to provide an approved inscription which will indicate the purpose of the valve.

Main Tank

A) One 50mm bore filter valve located near to the top of the tank.

B) One 50m bore filter valve located near to the bottom of the tank and diagonally opposite to the filter valve required against (A).

C) One 50mm drain valve with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained of oil as far as practicable.

D) One valve in gas actuated relay connection.

E) One valve at the conservator to cut off oil supply to transformer.

F) Separate oil sampling valve near to the bottom of tank and another at top of the tank.

Conservator Tank

G) One drain valve for oil conservator tank so arranged that the tank can be completely drained of all oil.

Tap Changer Tank

H) 50mm filter and 50mm filter drain valve as required.

Diverter Switch Tanks

I) One 50mm filter valve, one 50mm drain valve and one drain plug to be fitted to each tank. An approved oil sampling device shall also be provided and located near to the bottom of each tank.

Air Blast Oil Coolers

J) One 50mm filter valve at the top and one 50mm filter drain valve at the bottom of each section.

Blank flange plates or captive screw caps shall be fitted to all valves and pipe ends not normally connected in service.

Air release and drain plugs shall be provided as required.

q) Joints and Gaskets

All joint faces shall be machined or ground 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 except where the synthetic rubber is used as a bonding medium for cork or similar material or where metal inserts are provided to limit compression.

Gaskets are to be as thin as is possible consistent with the provision of a good seal and full details of all gaskets sealing arrangements shall be shown on the Plant drawings.

r) Pressure Relief Device

An approved pressure relief device of sufficient size for the rapid release of any pressure that may be generated in the tank and designed to operate at a static pressure lower than the specified hydraulic test pressure shall be provided.

The relief device is normally to be mounted on the tank, but if mounted on the cover, it is to be provided with a skirt to project at least 25mm into the tank to prevent gas accumulation.

If a diaphragm is used, it shall be of approved design and material and located above the maximum oil level.

A pressure equalizing pipe shall be provided between the pressure relief device and the oil conservator. Spring operated pressure relief device shall be provided with two sets of normally open contacts to initate alarm and trip circuits.

s) Breather

Each conservator vessel shall be fitted with oil seal type silicagel breather with replaceable elements. The breather shall be arranged at such a height that it may be readily accessible from ground level and suitable observation window to be provided in the breather. In view of the high humidity prevailing in Oman, silicagel breather shall be at least one size larger than the size for a temperate climate.

t) Earthing Terminals

Two earthing terminals, each capable of carrying the full lower voltage fault current for a period of not less than 30 seconds, shall be provided: They shall be located one on either side, and near to the bottom of the transformer to facilitate connection to the local earthing system.

The cooling plant shall be designed to have two banks of radiators each of 50% rated capacity and shall have independent facility for isolation from service.

u) Cooling Plant

Radiators and coolers shall be designed so that all painted surfaces can be thoroughly cleaned and easily painted in situ with brush or spray gun.

The design shall also avoid pockets in which water can be thoroughly cleaned and easily painted in situ with brush or spray gun.

The design shall also avoid pockets in which water can collect and shall be capable of with standing the pressure tests specified for the transformer main tank.

Where separate coolers are provided, the conservator tank specified in Clause 5.2(0) shall be counted thereon.

Preference will be given to offers of an arrangements whereby cooling radiators are mounted on seprate foundations and connected to the main tank by pipe work.

A valve shall be provided on the tank at each point of connection to the tank.

All coolers shall be suitable for mounting on a flat concrete base.

Valves in the oil flow and return connections to the coolers shall be mounted on the transformer tank.

Each cooler bank shall be provided with:

A) A valve at each point of connection to the transformer tank.

B) A valve in the main oil connection at the bottom of each cooler in addition to those mounted on the transformer tank.

C) Loose blanking plates to permit the blanking off of the main oil connection to the top.

D) A 50mm filter valve of the type specified in Clause 5.2 (n) at the top of each cooler.

E) A drain valve at lowest point of inter-connecting oil pipes.

F) A thermometer pocket, fitted with captive screw cap, in the inlet and in the outlet oil pipes.

G) Flanged air release plugs.

The oil piping shall be of approved material with machined flanged joints. Cast iron must not be used for oil pipes.

Copper pipe work shall comply with BS 61 or equivalent.

Dimensions of steel pipes shall be in accordance with BS 3600 : 1973 or equivalent and the drilling of all pipe flanges shall comply with BS 4504 : 1989 or equivalent.

An approved expansion piece shall be provided in each oil pipe connection between the transformer and the oil coolers.

It should be possible to drain any section of pipe work independently of the rest and drain valves shall be provided as necessary to meet this requirement.

Air blowers shall be complete with all necessary air ducting, and to reduce noise to the practical minimum, motors shall be mounted independently from the coolers or alternatively an approved form of anti-vibration mounting shall be provided.

It should be possible to remove the blower complete with motor without disturbing or dismantling the cooler structure frame work.

Blades shall be of galvanised steel unless otherwise approved and blades or runners fabricated to form hollow sections are not to be used.

Ducts and blower casings shall be made of galvanised steel of thickness not less than 2.6mm (14 SWG) and shall be suitably stiffened by angles, or tees.

Galvanised wire mesh guards shall be provided to prevent accidental contact with the blades. Guards shall also be provided over all moving parts. Guards shall be suitably stiffened by angles or tees.

Guards shall be designed such that neither blades nor other moving parts can be touched by test finger types II and/or III, 1-4 to BS 3042 : 1971 or equivalent. Where multiple fan cooling using small single phase motors is employed the motors in each cooling tank shall be grouped so as to form a balanced three phase load. Each motor or group of motors shall be provided with a three pole electrically operated contactor and with control gear of approved design for starting and stopping manually.

Provision shall be included under this contact for automatic starting and stopping from the contacts on with winding temperature indicating device as specified in Clause 5.4(a). The control equipment shall be provided with a short time delay device to prevent the starting of more than one fan, or group of fans in case of multiple fan cooling, at a time.

Where motors are operated in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring in a single motor.

The control arrangements are to be designed to prevent the starting of motors totalling more than 15KW simultaneously either manually ora automatically.

All contacts and other parts which may require periodic renewal, adjustment or inspection shall be readily accessible.

All wiring for the control gear accommodated in the marshalling kiosk together with all necessary cable boxes and terminations and all wiring between the marshalling kiosk and the motors shall form part of the contract works.

v) **Bucholz Protection**

Each transformer shall be fitted with a gas and oil actuated relay of approved make and pattern, having alarm contacts which close on collection of gas or low oil level condition and tripping contacts which close for oil surge conditions.

The contacts shall be wired to a weather proof terminal block on the bucholz protection, for connection by mineral insulated copper clad PVC sheathed cable (2.5 sq.mm) to terminal blocks in the marshalling kiosk described in Clause 5.3.

The circuits shall be electrically connected by PVC/PVC/SWA/PVC control cables (2.5 sq.mm copper conductor) to auxiliary ''Alarm" and ''Trip" relays on the remote tap change panel. The bucholz device shall be inserted in the pipe work between the main tank and conservator and provided with suitable valves on both sides of the device to facilitate easy servicing. The bucholz device shall incorporate a test cock for testing purposes.

A compressed air bottle fitted with a control cock, pressure gauge, a foot operated air pump and the necessary connecting rubber hose for compressed air tests on the bucholz device shall be included.

Each gas and oil-actuated relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.

To allow gas to be collected at ground level, a small bore pipe shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point approximately 140mm above ground level, where it shallbe terminated by a cock which shall have provision for locking to prevent authorised operation.

The design of the relay mounting arrangements, the associated pipework and the cooling plant shall be such that maloperation of the relays will not take place under normal service conditions, including starting or stopping of oil circulating pumps whether by manual or automatic control under all operating temperatures.

The pipework shall be so arranged that all gas arising from the transformr will pass into the gas and oil-actuated relay. The oil circuit through the relay must not form a delivery parth in parallel with any circulating oil pipe, nor is to be teed into or connected through the pressure relief vent. Sharp bends in the pipe work shall be avoided.

When a transformer is provided with two conservators the gas and oil-actuated relays shall be arranged as follows:

a) If the two conservators are connected to the transformer by a common oil pipe one relay shall be installed in the common pipe.

b) If the two conservators are piped separately to the transformer two relays shall be installed, one in each pipe connection.

The clearance between oil pipework and live metal is to comply with the requirements of BS 227.

w) **Terminal Arrangements**

The terminal arrangements for 132 and 33KV sides shall be as follows:

132KV	: Phase	: Outdoor bushing
132KV	: Neutral	: Outdoor bushing
33 KV	: Cable box	

132KV neutral bushing as well as the neutral of the 132KV windings may be rated to withstand power frequency voltage of 40KV.

Creepage of outdoor bushings shall be 40mm/KV of neutral withstand voltage.

Creepage of bushing inside cable box (dry type terminations) shall be 23mm/KV of highest system voltage.

x) Dry type termination eliminating the use of filling compound will be preferred. The terminations shall be accommodated in cable dividing boxes complete with cable gland, cable bonding clamps, earth bonding straps. Insulated cable glands shall be used for single core cables.

Cable clamp supports shall be fitted below the box (at a suitable height above ground level), and these should be nonferrous material.

The boxes shall be arranged for bottom entry of the cables. The 33KV cables box shall be suitable to receive six single core of compacted copper conductor 630 sq.mm copper XLPE insulated aluminium armoured PVC sheathed cables.

y) **On-load Tap Change Gear – General Requirements**

On load tap changers shall comply with IEC 214.

The on-load tap change gear shall be of robust construction and shall be unaffected in part of whole by the forces imposed by short circuit or other fault currents, operation vibration and temperature changes. It shall be capable of varying the effective transformation ratio of the transformer without producing phase displacement.

The tap changing shall be effected on the high voltage winding and the oil in the chamber housing the tap change selector switch may be in communication with the oil in the main transformer tank, but the tap change circuit making and breaking switch shall be accommodated in a separate oil filled chamber separated from the main transformer tank.

i) Duty

The duty rating on the switches shall have a continuous current rating equivalent to the continuous maximum rating of the transformer and shall give trouble free operations under Oman conditions. Limiting devices shall be provided to limit the operation of switches to the range of tapping specified. Tap changer shall be high speed resistor type. Tap changer shall comply with IEC 214 and shall be suitable for power flow in both directions.

Full details of the equipment offered shall be submitted with each offer. The equipment shall be designed to ensure that, when a tap change has commenced, it shall be completed independently of the operation of the control relays or switches.

In the event of failure of auxiliary electrical supply during a tap change or any other contingency which would result in the tap change not being completed, approved means shall be provided to safeguard the transformers and auxiliary apparatus.

ii) Selection

The equipment shall be arranged for operation giving the following selection:

A) ON-LOAD Automatic group operation from the master control (for two transformers).
B) ON-LOAD Manual Electrical Remote group operation (for two transformers).
C) Individual ON-LOAD Automatic operation of each transformer.
D) Individual ON-LOAD Manual Electrical Remote operation of each transformer.
E) Individual Manual Hand and Electrical Operation shall be provided in a suitable weather, vermin and insect proof marshalling kiosk.

Remote tap change control panel which shall be located in the control room shall include the following:

- Tap position indicator
- Tap changer "Raise" push button
- Tap changer "Lower" push button
- Tap changer in progress - white lamp - amber
- Tap changer out of step indication lamp
- Voltage regulating relay with time delay
- Tap changer control Auto/Non-Auto selector switch
- Master/Follwer/Individual Selector Switch
- Remote supervision tap change control selection
- ARV voltage reference adjuster
- Air forced cooling equipment running indication lamp - white
- Air forced cooling document alarm - amber.
- VT fail alarm - amber
- Supply voltage of OLTC failure - amber lamp
- 0-40 KV voltometer.

The automatic regulation of the 33KV voltage of the 132/33KV transformers shall be initiated by means of voltage regulating relay.

The relay shall be rated for AC 110 volts 50 cycles. A time delay element operated off 110V DC supply shall be included to give setting range between 10 and 120 seconds.

The relay shall be rated for AC 110 volts 50 cycles. A time delay element operated off 110V DC supply shall be included to give setting range between 10 and 120 seconds.

The relay sensitivity shall be adjustable to any value between 1.25 times to 2 times the transformer tap step percentage. The relay shall be made inoperative if the reference voltage falls below 80% of nominal value and shall be automatically restored for operation on recovery of the nominal voltage.

In the event of the transformers falling out of step, while operating in parallel, a device shall be incorporated in the control circuit, to make the automatic tap change in-operative; this device shall also set off an alarm to indicate the condition electrically at a remote point, apart from lighting the ''out-of-step" indication lamp provided on the existing panel.

iii) Inter-locks and Control

The equipment shall be arranged to comply with the following:

a) The hand gear operation of mechanism shall be inter-locked to prevent the electrical motor drive operation while the hand gear is in use.

b) It shall not be possible for any two electrical points to be in operation simultaneously.

c) Operation from any control switch shall cause one tap movement only unless the control switch is returned to the off position between successive operations.

d) All electrical control switches and hand operating gear shall be clearly labelled to indicate the direction of tap change.

e) The local control switches and other apparatus shall be mounted inside the marshalling kiosk.

f) A mechanical tap position indicator shall be fitted on the transformer and shall be visible from ground level. A device for registering the total number of tap change operations and a hand reset register device for counting tap change operations between period of maintenance shall be fitted.

g) A remote indicating device shall be provided for installation in the control room. The device shall indicate the tap position and shall be scaled 1-19.

h) The tap change mechanism shall be provided with additional set of ''clean contacts" wired to a suitable terminal blocks in the control panel, to transmit, ''tap position" to a ''remote supervisory and control center".

5.2 LOW LEVEL ALARM

The conservator tank of all main transformers shall be fitted with a low oil level alarm device. The device may be incorporated in the oil level indicator and shall be arranged to close a pair of contacts when oil level drops below a predetermined level. The alarm contact shall be cabelled to the marshalling krosk.

5.3 MARSHALLING KIOSK

Each transformer shall be provided with a Marshalling Kiosk located adjacent to the transformer. The Kiosk shall be of the outdoor type, of sheet steel construction, fitted with access doors, on from and rear. Alternatively

the Kiosk may be mounted on the transformer. The Kiosk must be dust, damp, rain and vermin proof and shall be designed for temperature conditions of Oman. The front access door shall be fitted with wire reinforced glass inspection panels. Locks and handles shall be fitted to the doors.

The Kiosk shall be accommodate the following:

1) Transformer oil temperature indicator Clause 5.4 (a).
2) Transformer winding temperature indicator Clause 5.4 (b).
3) Terminal blocks and test links for (1) and (2).
4) Local ''Tap change" selector and control switches.
5) Marshalling terminal blocks for connections between transformer auxiliaries and remote control panel.
6) Control switches, fuses, protective device associated with tap-change motor circuits, which normally cannot be accommodated in the ''Tap Change Motor" compartment.
7) The Kiosk shall be provided with heater elements suitably controlled by a switch, temperature and/or humidity relay duty relay.

5.4 INSTRUMENTS

a) Winding Temperature Indicator

A dial type indicator calibrated to show the temperature of the hottest region of the windings shall be provided. This device may be of the type comprising a current transformer, heating coil, hot oil pocket, temperature measuring device and arranged to produce the desired relationship between winding temperature and hot oil temperature. The indicator shall be fitted with two sets of fixed and moving contacts one for ''Trip" and one for ''Alarm", adjustable to close between the range of 60 Deg. C. to 120 Deg. C. The contacts shall re-open when temperature has fallen not more than 10 Deg. C of the set temperature.

For controlling external cooling fans, one more set of contacts shall be included. A maximum temperature pointer shall be incorporated with the indicator to show highest temperature reached and arranged for hand re-setting.

b) Oil Temperature Indicator

A dial type instrument together with capillary tube to indicate the temperature of oil in the hottest region of the Main Tank shall be provided.

The indicator shall be fitted with two separate sets of fixed and moving contacts, one for ''Alarm" and one for ''Trip", adjustable to close between the range 60 to 120 Deg. C. The contacts shall re-open when the temperature has fallen not more than 10 Deg. C.

A maximum temperature pointer shall be provided to show the highest temperature reached and shall be arranged for hand re-setting.

NOTE

The winding temperature indicator and the oil temperature indicator shall be accommodated in the Marshalling Kiosk described in Clause 5.4.

5.5 RATING AND DIAGRAM PLATES

Each transformer shall be provided with substantial diagram, rating and valve location plates and shall give all the information relating to the transformer, and cooling medium.

The following information shall be included:

- Rating in MVA
- Temperature rise by oil Deg. C.
- Temperature rise by reisstance Deg. C
- Volts at no load and normal tapping:
  - H.V. Side
  - L.V. Side
- Current at rated load and normal tapping:
  - H.V. Side
  - L.V. Side
- Impedance voltage at normal ratio
- Transforming ratio at each tap
- Location and function of all valves and reclose cocks or plugs. This plate shall if necessary, warn operation to refer to the maintenance instructions before applying vacuum
- Number of phases
- Diagram of connections
- Manufacturer's serial number
- Year of manufacture
- Frequency
- Vector group reference and diagram
- Weight of core and winding
- Weight of oil
- Total weight of transformer
- Contract Number
- Employer's name and address

The plates shall be stainelss steel or other approved material capable of withstanding the vigourous climatic conditions and shall not be less than 2.5mm thick and the marking shall be engraved thereon. The dimensions shall be to approval of the Employer.

5.6 CAPITALISATION OF LOSSES

The transformer no load and load losses and input to cooling plant (where applicable) will be capitalised and added to the tneder priceduring evaluation. The CAPITALIZATION will be based on the following:

a) No load losses	:	R.O. 800/- per KW
b) Load losses	:	R.O. 300/- per KW
c) Cooling plant	:	R.O. 200/- per KW

If the acceptance tests of the transformers show that the actual losses exceed the values stated in the Schedules of Technical Particulars, then the ''Excess Losses" will be capitalised according to the above assumption and the sum thus obtained deducted from the monies due to the Contractor as a penalty. For this purpose no tolerance will be allowed on the figures stated in the Schedule of Particulars and Guarantees.

In any case, the actual losses shall not exceed the figures stated in the Schedule of Technical Particulars by more than 10%.

The losses to be stated in the Schedule of Particulars and Guarantees shall be given without tolerance.

5.7 EARTHING AND AUXILIARY TRANSFORMERS

a) General

Earthing transformers shall be of the oil immersed ONAN type suitable for outdoor installation and are to have a main interconnected star 33KV winding which will be directly connected to the lower voltage terminals of the associated 63MVA 132/33KV transformer. The earthing transformer shall comply with BS 4944.

The neutral point of the interconnected star winding shall be brought out of the tank through a bushing insulator. This point may be isolated or connected to earth directly or through an impedance in order to provide an earthing point for the neutral of the 132KV system.

The earthing transformers shall also be provided with a star connected auxiliary winding arranged to give a 415/240 volts, 3 phase, 4 wire supply. The auxiliary winding shall have the continuous site rating of 315KVA and shall conform to BS 171 and IEC 76.

The earthing transformer shall be connected to IEC group symbol ZY11.

b) Electrical Short Circuit Characteristics

Earthing transformers shall, when operating continuously at any load upto continuous maximum rating of the auxiliary winding be capable of withstanding for a period of 3 seconds the application of normal three phase line voltage to the line terminals of the interconnected start winding with one line terminal and the neutral terminal connected solidly to earth.

The zero phase sequence impedance and resistance of the interconnected star winding under these conditions shall be as stated in the Schedule of Particulars and Guarantees.

Additionally, earthing and auxiliary transformers shall, when operating continuously at any load upto CMR, be capable of withstanding for 3 seconds the current obtained when a short circuit is applied between any or all of the lower voltage terminals with full line voltage maintained at the higher voltage terminals.

The foregoing conditions shall assume an initial winding temperature which is the sum of the maximum ambient temperature and the temperature rise obtained by continuous operation at CMR.

The interconnected star winding of each earthing transformer when at its maximum temperature due to continuous full load on the auxillary winding shall be designed to carry for 30 seconds without injurious heating an earth fault current not less than the full load lower voltage current of the main transformer to which it is connected.

c) Tanks and Fittings

Earthing transformers shall be provided with the following fittings:

A) Conservator vessel with removable end cover and primatic oil gauge.
B) Bucholz Protector.
C) One thermometer pocket with captive screw cap.
D) Silicagel Breather of the oil seal type at least one size larger than would normally be supplied for the use in a temperature climate.
E) Pressure relief device.
F) Filter valve and combined filter and drain device.
G) Oil sampling device.

H) Cable boxes on 33KV and 415V sides.

I) Rating and Diagram plates.

d) Auxiliary Winding

The 3 phase 4 wire auxiliary windings shall be terminated at a 3 pole combined switch fuse unit with bolted neutral link and gland entry for a 4 core XLPE insulated wire armoured PVC sheathed cable. This shall be accommodated in a lockable, fully weather proof compartment together with a neutral earthing link.

The purpose of the neutral earthing link is wto connect the 415 volts system neutral to earth. It shall be connected between the transformer winding end of the neutral link and a suitably located earthing terminal to which the system earth can be connected.

3 phases fuses shall be supplied with each transformer.

e) Tappings

The 33KV windings of the earthing transformers shall have tappings at + 2.5% or - 2.5% and + 5 or - 5% operated by an off circuit tapping switch, with clearly marked position indicator. Locking facilities shall be provided for locking only on a definite tap.

f) Rating and Diagram Plates

Each earthing transformer shall be fitted with plate complying generally with Clause 5.5. In addition to information called for in IEC 76/BS 171 the 30 second with fault current rating of primary winding with full load current on the secondary winding and zero phase sequence impedance of the transformer shall be given on the rating plate.

6.0 33KV NEUTRAL EARTHING EQUIPMENT

6.1 GENERAL

The 33KV neutral earthing arrangement shall be as shown on Drawing No. PL/SLD-P-03. The 33KV system neutral earthing equipment for each 63MVA transformer shall comprise:

- 1 Earthing Resistor 19.00 Ohms 1000 Amps for 30 secs
- 2 Earthing Isolators
- 2 Neutral Current Transformers

6.2 NEUTRAL EARTHING RESISTOR

The earthing resistor shall be metallic element type suitable for outdoor installation to provide earthing of 33KV three phase 50 Hz system neutral.
The housing for the resistor shall be of substatnial steel construction heavily galvanised.

The electrode shall be adequately insulated supported and designed to withstand fault operating conditions.

7.0 PROTECTION, CONTROL AND METERING

7.1 GENERAL

Separate control and relay boards and integrating metering panel shall be provided and installed in the substation control room.

Control boards shall incorporate all necessary control and indication facilities for the operation of the plant and equipment at the substation.

Relay boards shall incorporate all the protective gear and the metering panel, the integrating and summation metering equipment.

Each cubicle shall form a complete enclosure accommodating the equipment associated with only one circuit of main equipment.

The cubicles shall be self supporting, floor standing and shall provide for bottom entry of power and control cables, through bottom plate and compression type brass glands for single wire armoured power and multicore control cables.

Panels shall be regidly 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 2.5m. Operating handles and locking devices shall be located within the operating limits of 0.95 m and 1.8 m above floor level. All panels shall be fitted with padlocks. The minimum height for indicating instruments and meters shall be 1.5 m unless otherwise specified.

Panels shall be mounted on an approved form of antivibration mountings wherever necessary.

All panels and cubicles shall be vermin-proof. All cable entries to equipments 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.

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.

All nuts, bolts and washers shall be plated.

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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 panels without the aid of a key after they have been locked from the outside. Hinges shall be of the lift-off type.

The bottom 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.

Each panel shall include rear access doors and door-operated interior lamp, and be clearly labelled with the circuit titled at front and rear, with an additional label inside the panel. Panel sections accommodating equipment at voltage higher than 100 V shall be partitioned off and the voltage clearly labelled. 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 lables.

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

For suites of panels interpanel bus wiring shall be routed through apertures in the sides of panels and not via external multicore cabling looped between the panels.

The cubicles shall be provided with close fitting lockable and lift-off rear access doors hinged to open through 180 Deg. C. The inside shall be finished with a matt white surface and shall include a lamp controlled by a door operated switch. The outside shall be finished semi-matt to colour Eau de NSl BS 381 C No. 216.

Relays shall be provided with **LED*** flag indicators, phase coloured where applicable. Indicators shall be of 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 which rely for their operation on an external DC supply shall utilise for this purpose the trip supply of the associated circuit breaker. This supply shall be monitored at the relay and an alarm provided in the event of failure.

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.

Approved means shall be provided on the relay panels for the testing of protective relays and associated circuits. If injection test plugs are required for this purpose the same shall be supplied.

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

To minimise the effect of electrolysis, relay coils operating on DC shall be so connected that the coils are not continuously energised from the positive pole of the battery. Suitable CT short circuiting facility shall be provided in the relays terminal blocks.

LED* : Light Emitting Diodes

PROTECTION

a) General

Protection equipment shall be designed and applied to provide maximum discrimination between faulty and healthy circuits. All equipment shall remain in-operative during transient phenomena which may arise during switching or other disturbances to the system.

Relays shall be of approved makes and types, electromagnetic/electronic complying with BS 142, IEC Publication 255, shall have approved characteristics and be flush mounted draw out type in dust proof cases.

The construction of the relays shall be sturdy and shall be such that all parts are readily accessible for easy adjustment.

Relay contacts shall be suitable for making and breaking the maximum currents which they may be required to control in normal service. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the realy mechanisms shall be unaffected by vibration or external magnetic fields.

b) Distance Protection

Distance protection for 132 and 33KV overhead line feeder circuits shall be of high speed type with 1 amp rating.

To ensure necessary safety of the protection system, the following criteria shall be strictly observed:

- Individual measuring elements for each zone and for each type of fault should be provided, without the need for switching any current or voltage circuit.

- Protection shall detect all types of phase and earth faults. Protection shall detect close in 3 – phase faults accurately.

- A switch on the fault facility shall provide an instanteous trip if the line is energised onto a three phase fault with line VT's.

- Transient over-reach shall be reduced to less than 5%, thus allowing increased zone 1 setting, without maloperation on external faults.

- Measuring elements of the polarised MHO type shall be provided.

- Every kind of fault shall be measured separately, without change over of measuring system.

- Undesired tripping on power swings shall be avoided.

- To detect faults with currents less than the rated current, the protection shall be equipped with impedance starters.

- For 33KV feeder circuits switched version of the distance relay covering all kinds of phase and earth faults with a single common measuring element with zone switching would be considered adequate and acceptable.

c) Pilot Wire Protection for 33KV Cable Circuits

For 33KV underground cable feeder circuit, pilot wire protection 15KV insulated to match the Solkor RF protection provided at the other end.

d) 132KV Busbar and Breaker Back-up Protection

The protection system shall be able to work on CT's which may have different ratios. The protection system shall preferably be of the electronic type to achieve the lower possible response time (less than 20 ms).

To ensure the necessary safety of the protection system the following criteria shall be strictly observed:

- CT circuits shall not be switched via the auxiliary contacts of the busbar isolators.

- Two independent measuring criteria shall be used both of which shall be independent of the voltage to ensure in case of a metallic short circuit (voltage 0) safe tripping.

- Full selectivity shall be guaranteed for each busbar zone. All busbar coupling circuit breakers as well as sectionalising circuit breakers shall be incorporated with the protection system to achieve the necessary selectivity.

- The complete protection system shall be fully tested in the factory, the only remaining work on site being the connection of the auxiliary cables.

- An automatic test facility shall be provided which will automatically test the protection system approximately every week. Furthermore, the start of this test shall also be possible by manual operation.

- As the short circuit currents within the network are, under low load condition rather small, the protection system shall also work at short circuit currents in the range of the maximum possible operating current.

Incorporated with the electronic busbar protection shall be a breaker back-up protection which shall work and be incorporated with the busbar protection as follows:

- The isolator replica of the busbar protection shall be used to guarantee a selective protection of the busbar zones.

- Two independent measuring criteria shall be used to prevent undesired tripping.

- After a delayed time the breaker back-up protection shall give a tripping command to a separate tripping coil of the same breaker to operate the circuit breaker. If this has no effect the protection shall give a different tripping command after a second delay time to all circuit breakers of the concerned busbar zone to interrupt power supply.

- In addition to the above criteria, the following should be observed for both busbar and breaker back-up protection.

- The extension of the protection system shall easily be possible. The protection shall also be wired for the whole number of feeders required in the future. Thus, later on the respective printed cards or parts can be easily fitted to the protection.

Alternatively, high impedance circulating current busbar protection will be considered for 132KV busbar and breaker back-up protection, similar to 33KV busbar protection as described in (e) below.

e) **33KV Busbar Zone Protection**

High Impedance Circulating Current Busbar Protection

33KV switchgear shall be provided with a high impedance balanced busbar protection scheme and shall be capable of extension as the system developes.

The protection shall be capable of detecting 3 phase, phase-phase and phase-earth busbar faults and have two independent sets of protective equipment for each zone, one as a check on the fault sensing of the

other. Both sets of equipment must operate to initiate tripping in the event of a busbar fault in any zone.

The check set of equipment may be common to all discriminating zones to form one overall zone.

In addition, automatic and continuous supervision of the current transformer circuits shall be provided to give warning of the out of balance current having reached an undsirable value.

The supply shall include the provision of all necessary current transformers, auxiliary switches, relays, panels and multicore cable marshalling boxes.

Each zone of protection shall be capable of being switched out of service separately whilst leaving the other zone or zones in service.

The following indication lamps shall be installed on the busbar protection panels:

a) Busbar fault
b) Protection defective
c) "Protection in Service" for each zone
d) "Protection out of Service" for each zone
e) Trip supply faulty

Of these, the following shall initate an audible alarm:

a) Busbar fault
b) Protection defective
c) Trip supply faulty

In the event of a busbar fault, means shall be provided by flag indications on relays to indicate, the zone in which the fault has occurred.

Trip isolation links for each circuit shall be provided on the control and relay panels.

Suitable CT test and change-over links shall be provided at or in the marshalling kiosks adjacent to each circuit breaker.

These links shall enable the current transformers to be shorted and/or isolated from the protection in order that testing and maintenance can be carried out. Links are to have a switch protective cover and warning label.

f) Overcurrent and Earth Fault Inverse Time Protection

Overcurrent and earth fault relays shall be of the induction disc/electronic inverse/definite minimum (IDMT). Directional relays of this type shall incorporate directional element which gives maximum torque in a closing direction for an operating current of 45 Deg. lagging power factor when applied to transformers and 30 Deg. for plain feeders.

Overcurrent relay shall have a current setting range from 50 to 200% of rated current in steps of 25% and the time setting adjustable from 0 to 3 seconds at 10 times the normal operating current. Inverse time

earth fault elements shall comply with the foregoing but shall have a range of settings from 10 to 40% of rated current in steps of 10%.

g) Transformer Overall Protection

Transformer overall protection shall be of the biased differential type to cover 132 and 33KV windings for phase and earth faults.

The protection shall incorporate harmonic restraint and shall remain stable during magnetising inrush surges without introducing any intentional time delay during fault operation.

The minimum operating settings shall be not more than 30% of rated full load of the current transformers.

The protection shall remain stable under maximum through fault conditions corresponding to rated system short circuit level on any tap position.

h) Transformer Restricted Earth Fault Protection

Transformer windings shall be provided with restricted earth fault protection. Relays shall preferably be of the high impedance type with necessary protection against over voltages.

Relays shall have maximum sensitivity and minimum operating times consistent with stability for faults outside the protected zone and magnetising inrush surges.

132 KV neutral current transformers shall be incorporated in the high voltage neutral bushings of transformers and 33KV neutral current transformers in the metal clad neutral earthing switchgear.

The line and neutral current transformers shall have identical turns ratio and matching magnetisation characteristics.

i) Stand-by Earth Fault Protection

For thermal protection of fault current limiting 33KV neutral earthing resistors in the event of an uncleared fault two stage definite time stand-by earth fault protection shall be provided on the 33KV neutral circuit with current setting range 10% to 40% of the rated current, and time setting adjustment from 2 to 30 secs.

j) Definite Settings and Definite Time Delay Earth Fault Protection

Transformer neutrals (132KV) which are solidly earthed shall be provided with neutral earth fault protection of a definite current/definite time delayed type.

The relays shall be supplied with adjustable settings such that protection can be provided for the maximum proportion of the windings.

A time delay relay with two stages of adjustable settings shall be provided and the characteristics and setting range of both relays shall be to approval.

k) Bucholz Protection

Transformers shall be fitted with Bucholz devices. The Bucholz device will be of the two element type giving operation under gassing and under surge conditions.

All necessary flag indication tripping relays and alarm relays associated with this protection shall be supplied and connected.

7.3 AUTOMATIC RECLOSE EQUIPMENT

a) 132KV Overhead Line Feeders

At present, auto reclose shall be provided on 132KV and 33KV overhead line feeders and shall be initiated only for zone 1 phase to phase and zone 1 phase to earth faults from the 132KV or 33KV distance protection for these lines.

Auto reclose shall be blocked for all three phase faults and any zone 2 or zone 3 fault and also following the operation of the 132KV or 33KV feeder backup relays.

The range of dead times i.e. the delay between tripping due to a fault and reclosing the circuit breaker, shall cover the range 2-25 seconds for 132KV and 0-300 sec. for 33KV and the range of reclaim times shall be suitable for the circuit breakers offered.

After the 132KV breakers at both ends have been tripped due to a zone 1 phase to phase or phase to earth line fault detected by distance protection relays at either end, the feeder will be re-energised from one end after the expiry of the reclose dead time followed by reclosing of the breaker at the other end after a predetermined time interval which shall not be completed unless the system is in synchronism i.e. the line has been energised and the check synchronising relay permits reclosure.

b) 132KV Overhead Line Transformer Feeder Circuits

The 132KV transformer feeder circuits shall be controlled by 132KV breakers at the substation, trip with autoreclose on the 132/33KV transformer 33KV breaker at the receiving end shall be initiated by zone 1 phase to phase and phase to earth faults from the 132KV distance protection at the substation.

Auto reclose shall be blocked for all three phase faults and any zone 2 or zone 3 fault and also following the operation of the 132 overcurrent and earth fault relays at the substation. Similarly, if the 132KV line fault is of permanent nature, auto reclose of the 132KV circuit breaker at the substation shall be blocked.

After the 132KV breaker at the substation and the 33KV transformer breakers at the receiving end have been tripped due to a zone 1 phase to phase or phase to earth line fault detected by distance relay at the substation the feeder transformer shall be energised after the expiry of the reclose dead time.

c) The auto reclose scheme shall provide for selection of ''auto reclose on" or ''auto reclose off" and operations will normally be single shot with repetitive reclose cycles.

The auto reclose equipment shall be arranged to lock out and sound an alarm after the unsuccessful reclose attempt.

The relays shall have provision for adjusting the dead and reclaim times, the range of adjustment being suitable for the protective gear and circuit breaker types employed.

A counter to record the number of oper'ations shall be provided.

The reclose relays shall in all cases incorporate means for locking out the circuit breaker after predetermined number of reclose cycles for circuit breaker maintenance and to initiate an alarm when this situation is approaching.

7.4 METERING

a) General

Statistical metering shall be installed on the 33KV side of 132/33KV transformers. Each 33KV circuit shall be equipped with a commercial grade integrating KWH meter including maximum demand indication and KVARH meter. Non reversing ratchets shall be fitted. Summation equipment shall be provided and all equipment shall be installed on a separate panel. Requirements are shown on Drawing No. MEW/132KV/63MVA/7

b) KWH Meters

Kilowatt hour intergrating meters shall be of the induction disc 3 phase unbalanced load type.

Case shall be subject to approval and shall be finished in bright black enamel.

Kilowatt hour meters shall be provided with a maximum demand indication on a pointer dial arranged for half hour resetting. The half hour resetting signal shall be obtained from a time clock.

33KV metering shall be fitted with a transmitting unit to provide a pulse or switched output to operate a summation scheme and to transmit information (magnitude and direction) via a future supervisory system to a central control area.

c) KVARH Meters

KVARH meters shall be of the induction disc three phase unbalanced load type of the same manufacture as the KWAH meters.

KVARH meters shall be equipped with impulsing contacts having a pulsing rate of 10 KAVRH per pulse.

d) Summation Equipment

The summated half hourly KW demand shall be recorded at 30 minute intervals on a printometer. The integrated total KWh shall be separately indicated on a total register. The 30 minutes printing interval shall be signalled from the time clock used for the maximum demand indicator.

The KVARH pulses shall be summated and the integrated total KVARH shall be indicated on a register.

Both KVARH and KWh summated values shall be used to drive a total KVA demand indicator which shall be integrated over a 30 minutes period.

The total KVA demand shall be indicated on a pointer dial. The pointer shall be reset after the integration period which will be signalled as for the KW maximum demand indicator described above. A manually reset KVA maximum demand pointer shall be included.

The summated KVAH pulses shall be registered on the printometer.

e) **Time Clocks**

The time clock used for measuring the half hour intervals shall be operated from the 110V DC supply.

f) **Construction**

All metering equipment shall be suitable for panel mounting in flush draw-out cases and be in accordance with the general requirements of the specification.

g) **Auxiliary Supplies**

Auxiliary equipment should be suitable for operation from the 110V DC supply.

h) Each 33KV feeder shall be equipped with a commercial grade integrating KWh meter including maximum demand indication.

7.5 CONTROL BOARDS

a) **General**

Separate control boards shall be provided for 132KV switchgear and for 33KV switchgear.

Control panels shall provide all facilities necessary for the safe and effective control of the plant and equipment being supplied under this Contract.

132 and 33KV circuit breakers shall be provided with electrical controls at the circuit breaker, suitably mounted on local control cubicles for 132KV and infront of switchgear panels for 33KV for use under maintenance or emergency conditions. A multiple lockable changeover selector switch shal be provided at the circuit breaker and labelled "Local" and "Remote".

When the circuit breaker is selected to the "Local" position, it shall not be possible to open or close the breaker from remote positions.

132 and 33KV circuit breakers shall be capable of being controlled from the substation control room and also in the future from a central control room via a remote supervisory system.

Circuit breaker control switches on remote panels should be incorporated with the discrepancy type indication switches. Changeover selector switches for remote/supervisory control shall be multiple lockable and labelled "Remote" and "Supervisory". Selector switches shall be installed on the appropriate circuit breaker control panel. All terminals from the selector switch for the future supervisory system shall be wired to the control panel terminal block. Controls at each substation shall be operated at 110V DC.

b) **Indications**

A single line schematic mimic diagram showing the main power equipment and connections shall be provided on 132 and 33KV control panels. The diagram shall incorporate discrepancy type indication switches to show the position of circuit breakers, isolators and line earthing links. Discrepancy indication switches shall be provided for all circuit breakers, isolators and line earthing links except where specified.

The diagram shall be at a convenient height to allow easy operation of discrepancy switches.

Control boards and panels shall except where specified otherwise, be finished in semi matt Eau De Nil BS 381 C No : 216 colour. System voltage shall be distinguished by the following colours on the mimic diagram:

System Voltage KV	Colour to BS 381 C
132	Black
33	Green No : 221
11	Signal Red No : 537
0.415	Light Orange No: 557

Control switches and push buttons shall comply with OES 11.

Position indication signals of switches and breakers for transmission by a future supervisory control scheme shall be derived from separate normally open and closed auxiliary contacts, provided and connected upto terminal blocks in the associated control panels. A discrepancy condition shall sound a buzzer in the control room.

All discrepancy lamps shall be arranged to light and give an audible alarm when the position of the equipment; e.g. circuit breaker is at variance with that of the indicator and shall be arranged to extinguish when the indicator is set to the correct position.

c) Trip Circuit Supervision

Relays shall be provided to monitor continuously the trip circuit for each circuit breaker and provide an alarm in the event of failure of continuity of supply. Series resistances shall be provided as necessary to ensure that the trip coil will not operate in the event of short circuit of any one component of each monitoring circuit.

The relays shall be designed such that under normal healthy conditions they should be energised. If the tripping supply fails or the trip circuit becomes open circuit the relay should "drop off" after a short time delay and initiate audible and visual alarms.

The time delay on "drop off" should be suitable to prevent spurious operation due to transient trip supply voltage reductions or tripping of other circuits.

d) Synchronising

Manual/Remote synchronising facilities on the 132 and 33KV circuit breakers shall be provided.

The system provided is to be such that the synchronising circuit must be established before the circuit breaker can be closed.

Synchronising check relays to prevent circuit breaker closing out of synchronism are to be included. Synchronising check relays shall check the phase and magnitude of the voltage difference at synchronising, to prevent inadvertent manual closing outside acceptable limits.

Means shall be provided at the control panel to by-pass this relay while switching dead equipment or lines, together with warning lamp indication that the relays are out of circuit.

Synchronising check relays shall be suitable for the use with a future remote supervisory control scheme, without further modification.

e) **Indicating Lamps**

Normally, energised indicating lamps if employed shall in genral be energised from the station LVAC supply via an auxiliary transformer. In addition, facilities shall be provided for manual changeover from the AC supply to the station DC supply via an automatically resetting switch arranged to reset after a time interval of approximately five minutes.

Common switches shall be provided in approved locations so that all normally lit indicating lamps and the audible alarm can be switched off. Auxiliary contacts on the common substation switch shall be arranged to cut out the flasher relays of alarm circuits to prevent unnecessary wear on flasher relays.

Lamp fittings shall allow adequate ventilation and allow for easy removal for replacement of the lamp in the event of failure.

Lamp test facilities shall be provided so that all lamps on one panel can be tested simultaneously by operation of a common key. Where alarm facia are specified, all alarm and monitoring indications shall be incorporated in the facia.

Indicating lamps and fittings shall generally be in accordance with OES 11.

f) **Alarm Schemes**

Alarms shall be sub divided into trip and non trip (urgent and non urgent) function and each arrange to operate a common bell or buzzer as specified.

Means shall be provided for silencing audible alarm whilst leaving the bell or buzzer free to sound if any other alarm circuit is energised.

Alarm indicating lamps shall remain alight until cancelled by the resetting of the devices initiating the alarms or the operation of a separate cancellation switch as appropriate.

Where devices initiate alarms when breakers tripped manually the circuits shall avoid unnecessary display of the alarms.

Annunciation for each circuit shall be provided and mounted on the associated control panel. Common alarm facia shall be of the multi window type (preferably with individually replaceable windows) with individual alarms operated from self seal-in relays and indicated by flashing illumination of an inscribed transparent window. Operation of a common accept key shall cuase the light to become a steady and silence the audible alarm due to be cutout by the auxiliary contacts specified in 'e' above. Resetting of the interposing alarm relays shall only be possible after the initiating contacts have been reset.

The supply shall include all necessary interposing relays, cables, wiring and channels in the power line carrier system necessary to enable four group alarms to be transmitted to supervisory control center.

a) Trip alarm
b) Non-Trip alarm
c) Spare
d) Spare

When testing the lamps, provision for blocking transmission of alarms to Remote Control and resetting after test shall be provided.

g) **Fuses and Links**

Fuses and links shall be in accordance with OES 11. Fuses shall be of the high rupturing capacity cartridge type. Fuse holder shall be designed to lock the cartridge firmly into position.

Fuses and links shal lbe positioned at the bottom of the front face of relay boards but at the rear of control baords on the outside of the cubicle and above the access door.

Carriers and bases for 16 amp fuses shall be coloured green and those for 6 amp fuses sahll be black. Link carriers and bases shall be white or other distinctive colour.

Miniature circuit breakers are acceptable in lieu of fuses.

h) **Earthing**

Each control relay or metering panel shall be provided with a copper earth bar of not less than 100 sq.mm cross section and arranged so that the bars of adjacent panels can be joined together to form a common bus. The common earthing busbar of control and relay panels shall be connected to the main station earthing system via a copper earthing connection.

i) **Test and Earth Links**

Test facilities shall be provided for each current and voltage transformer secondary circuit, in order to give access for testing of protection relays and associated circuits. The facilities shall comprise test terminals of an approved type for front of panel mounting with provision for short circuiting and earthing current transformer secondary circuits by means of a switch or by movement of secondary links from their normal operating position.

Each current and voltage transformer circuit shall be earthed through a removable link at one point only. Current transformer circuit links shall be arranged so that the current transformers can be safely short circuited whilst the circuit is on load.

Links shall be clearly labelled, mounted in accessible positions and the link covers coloured white.

j) **Multi-core Cables**

Protection and control schemes should, in general, be based on the use of single 2.5 sq.mm cores, except where 0.9 sq.mm telephone cores are specified.

7.6 SUPERVISORY CONTROL AND TELEMETERING

MARSHALLING CABINETS

7.6.1 General

The supply of separate floor mounting marshalling cabinets and all wiring from the switchgear, control and relay panels to these cabinets for all connections to the remote control and supervisory equipment is included in this contract. These cabinets will form the interface between the substation and the remote supervisory control center.

Terminals for current transformer circuits are to incorporate short circuiting links on the switchgear side of the terminals. All terminals shall incorporate open circuiting links to permit isolation and testing of circuits to the telemetering and control equipment.

Where provision for transducers is specified, a block of ten (10) spare terminals shall be provided adjacent to the current and voltage transformer wiring terminals to enable the future Supervisory Control and Telemetering

Centre to marshall output leads from transducers. Five spare terminals shall be provided for transformer tap position indication transducer output.

Marshalling cabinet shall be located in PLC room.

7.6.2 Transmission of Alarms and Indications

Wiring, auxiliary contacts etc. to enable the following signals (wherever applicable) to be transmitted by the telemetering and supervisory equipment is to be cabled to the marshalling cabinet:

a) For Each Feeder Circuit Breaker

Alarm indications for:-

i) Main protection trip
ii) Back-up protection trip (over current, earth fault, distance protection zone 2 or 3 etc., connected to one common alarm circuit)
iii) Auto reclose initiated (where applicable)
ib) Auto reclose lockout (where applicable)
v) Circuit breaker inoperative
vi) Trip circuit fail
vii) VT fail
viii) Protection pilot or channel fail (as applicable)
ix) Intertrip receive (where applicable)
x) 110V DC supply fail
xi) Cable oil pressure low alarm (feeder with oil filled cable only)
xii) Cable oil pressure low trip (feeders with oil filled cable only)
xiii) Space for 5 future alarms

"ON/OFF" indications for:

i) Circuit breaker
ii) Busbar isolators
iii) Line or cable isolator
iv) Line or cable earth switch
v) Supervisory control in service
vi) Local/Remote control in service

For transducer connections for remote measurements:

i) 3 Phase + Neutral current transformer connections
ii) 3 Phase + Neutral voltage transformer connections

b) For Each Transformrer Circuit Breaker

Alarm indications for:

i) Main protection trip (including cable low oil pressure trip if applicable)
ii) Back-up protection trip
iii) Circuit breaker inoperative
iv) Trip circuit fail
v) Intertrip receive
vi) Transformer alarm (including cable low oil pressure alarm if applicable)

vii) 110V DC supply fail
viii) Trip relay operated
ix) Space for 5 future alarms

"ON/OFF" indications for:

i) Circuit breaker
ii) Busbar isolators
iii) Cable or transformer isolator
iv) Cable or transformer earthing switch
v) Supervisory control in service
vi) Local/Remote control in service

For transducer connections for remote measurements:

i) 3 Phase ✘ Neutral current transformer connections
ii) 3 Phase ✘ Neutral voltage transformer connections

c) **For Each Bus Coupler or Bus Section Circuit Breaker**

Alarm indications as follows:

i) Main busbar protection trip
ii) Reserve busbar protection trip (if applicable)
iii) Busbar protection fail
iv) Back-up protection trip
v) Circuit breaker in-operative
vi) Trip circuit fail
vii) 110V DC supply fail
viii) Trip relay operated
ix) Space for 5 future alarms

"ON/OFF" indications for:

i) Circuit breaker
ii) Busbar isolators
iii) Busbar earthing switches
iv) Supervisory control in service
v) Local/Remote control in service

For transducer connections for remote measurements:

– 1 Phase current transformer connection

d) **For Each Transformer**

Indications as follows:

i) Control selection ("Auto/Manual")
ii) Control selection ("Supervisory On")
iii) Tap change in progress
iv) Tap changer incomplete alarm

v) Tap changer out-of-step
vi) Tap position indication (''Potential Free" contacts on multi-position stepping switch)
vii) Space for 5 future alarms or indications

e) For Each Capacitor Bank (where provided)

Alarm indications for:

i) Capacitor protection trip
ii) Capacitor alarm
iii) Circuit breaker in-operative
iv) Trip circuit fail
v) 110V DC supply fail
vi) Space for 5 future alarms

''ON/OFF" indications for:

- Circuit breaker

f) For Station Alarm Panel or Desk

Alarm indications for:

i) AC supply to 110V DC battery charger fail
ii) AC supply fail
iii) Alarm DC supply fail
iv) Battery alarm
v) Telecommunications fail (urgent)
vi) Telecommunications fail (non-urgent)
vii) Under frequency relay operated
viii) Station attended/unattended
ix) Fire protection operated
x) Space for 5 future alarms

g) For Mains Failure Stand-by Plant (where provided)

Alarm indications for:

i) Engine trip
ii) Alarm
iii) Fail to start
iv) Battery charger fail
v) DC Control supply fail

Indications for:

- Stand-by plant running

h) For Each 33KV Neutral Isolator

- Indication ''Open/Closed".

7.6.3 Reception of Remote Controls

Wiring to enable the following signals to be received from the telemetering and supervisory equipment is to be cabled to the marshalling cabinets:

a) Control (trip/close) of all circuit breakers
b) Control (open/close) of all power operated isolators
c) Control (raise/lower) of all on-load tap changers
d) Control (start/stop) of mains stand-by plant
e) Resetting of electrically reset type trip relays

Interposing relays are to be provided in the control or relay panels with contacts capable of handling the switch-gear tripping and closing currents. The operating coils of these relays are to be suitable for operation from the substation 110V battery.

7.6.4 Tele-Protection Signals

Cabels for the Tele-Protection signals between the protective relays panels and the Tele-Protection signalling equipment are to be provided and installed.

At the Tele-Protection signalling equipment end, the cables are to be terminated in the cable glands, cable cores identified and marked with identification ferrules. Cable glands are to be provided. Cable cores to be connected to terminals of the Tele-Protection equipment. Separate cables are to be used for each Tele-Protection channel.

At the protective relay panel, the cables for the Tele-Protection signals are to terminate on terminals which are wired directly to isolating links mounted on the front of the relay panel. The purpose of these links is to enable the Tele-Protection equipment to be readily isolated from the protective relays and the 110V DC tripping and control supplies. Disconnecting links incorporated in the terminal blocks will not be acceptable for this purpose.

A two position test switch (''Test/Normal") is to be installed on the front of the relay panel to enable the functioning of the inter-tripping channel to be tested. The switch is to be lockable and provided with a lock and duplicate keys. An indication lamp is to be provided for indicating that the test switch is in the ''test" position. A push-button is to be provided to initiate a test trip signal to the Tele-Protection equipment. A second indicating lamp or an auxiliary relay shall be provided to indicate that a test trip signal has been received.

A two position test switch (''Test/Normal") is to be installed on the front of the relay panel to enable the functioning of the inter-tripping channel to be tested. The switch is to be lockable and provided with a lock and duplicate keys. An indication lamp is to be provided for indicating that the test switch is in the ''test" position. A push-button is to be provided to initiate a test trip signal to the Tele-Protection equipment. A second indicating lamp or an auxiliary relay shall be provided to indicate that a test trip signal has been received.

7.6.5

The size of supervisory panel should be such as to accommodate specified number of current, Vav/Watt and other transducers. The preferable general arrangement of supervisory panel will be such that transducers are installed in central portion in multi vertical rows with all a.c. and control wiring as vertically arranged terminals on the sides and transducer output wiring at the centre where transducers are not specified as part of supply, necessary space provision for mounting of transducers and wiring in future to be kept.

8.0 BATTERIES, CHARGERS, DC SWITCHBAORDS

8.1 GENERAL

Two 100% duty batteries, battery charging equipment and one DC switchboard shall be provided.

All batteries, chargers and distribution equipments shall be suitable for switchgear tripping and closing duties, alarm and indications and emergency lighting requirements.

8.2 DC SYSTEM ARRANGEMENT

Nominal voltage shall be 110V DC and the voltage measured at the main distribution switchboard shall not vary by more than plus 20% and minus 10% of the nominal voltage when operating in accordance with the requirements of this section.

The schematic arrangement of the main DC system shall comprise distribution board, automatic float charger, boost charger and two 100% duty batteries. Each battery shall be connected to the main distribution board via a double pole changeover contactor.

This arrangement avoids applying over voltages to the connected load when a battery is being boost charged by switching that battery from the distribution board to the boost charger.

The batteries and chargers shall be arranged such that under normal conditions i.e. with A.C. supplies available to the chargers, both chargers operate in parallel to supply the specified D.C. load and at the same time automatically float charge the respective batteries to keep them fully charged. With one charger out of service the other shall be able to fulfill the full D.C. load requirements and at the same time the total battery float charge requirements. It shall not be possible to switch more than one 100% capacity battery and one charger out of service at one time.

The 110V batteries, chargers and distribution switchboard shall be provided to operate the control, alarm and indication schemes at the substation. All DC equipment for the carrier equipment shall be as specified in sections.

8.3 TYPE OF BATTERIES

Batteries shall be of the nickel cadmium alkaline type with cases of plastic. The battery to comply IEC 623: 1978 and shall be designed for a life of 25 years under site conditions.

Cells shall be numbered consecutively and terminal cells marked to indicate polarity.

Cells shall be marked with the following:

- Manufacturer's name and code
- Year and month of manufacture
- Voltage and nominal capacity at the 10 hour discharge rate
- Electrolite shall be potassium hydroxide conforming to BSS 5633

8.4 BATTERY DUTY

Each battery shall have sufficient capacity to supply the following loads for the periods specified with the chargers out of service.

Emerging lighting – six hours
Control and relay panels normal DC loading – eight hours

At the end of the eight hours the battery shall have sufficient capacity to complete the operations listed below, at the end of which duty the system voltage shall not have dropped below 90% of the nominal voltage with the above standing loads connected.

1. Two closing operations on all circuit breakers in the station.

2. Two tripping operations on all circuit breakers in the station, with simultaneous stripping of all circuit breakers in any one busbar protection zone.

3. Charging of DC motor wound circuit breaker closing springs (where applicable) to enable the closing operations to be carried out.

The electrolyte capacity and general design of the batteries shall be such that the inspection and maintenance including topping of the electrolyte, shall be at intervals of not less than twelve months.

8.5 BATTERY MOUNTING CONNECTIONS AND ACCESSORIES

Batteries shall be mounted in doube tiers in framed timber stands of robust construction. The stands shall be treated with electrolyte resisting enamel or gloss paint and any metal fittings shall be painted so that they will not be exposed to corrosion.

The cells shall be arranged in the tiers so that each cell is readily accessible for test and inspection. The stands shall be mounted on porcelain insulators and be so dimensioned that the bottom of the lower tier is not less than 300mm above the floor.

Batteries shall be supplied and erected complete with all necessary connections and cabling. Connections between tiers, between end cells and between porcelain wall bushings hall be of solid copper rod of suitable cross section supported on porcelain electrolyte resisting enamel gloss paint. Disconnecting links shall be provided for each battery at the terminals.

Before jointing, joint faces shall be bright metal, free from dirt and shall be protected by a coating of petroleum jelly.

Each battery installation shall be provided with a durable instruction card and a full set of test accessories, mounted in a strong wooden box. One syringe hydrometer shall be included for each nickel cadium alkaline battery installation.

Suitable containers shall be provided for making up electrolyte for each type of battery.

8.6 BATTERY FUSES

Cartridge fuses shall be provided in both positive and negative leads and positioned as close to the battery as possible and shall be rated for at least three times the maximum battery discharge current at the highest operating voltage.

The two fuses shall be mounted on opposite ends of the battery stand or rack. These fuse links shall comply with BS 88 clause DC 40 and shall be bolted in position without carriers.

Fuses shall be contained in poly carbonate fume proof boxes.

Warning labels shall be fitted to warn personnel of the danger of removing or replacing a fuse whilest the load is connected and that fuses should not be removed immediately following boost charge due to the possible ignition of hydrogen gas.

It shall not be possible to leave the battery disconnected without some local/remote indication that such a state exists.

8.7 CONTROL AND CHARGING EQUIPMENT

Each battery charging equipment shall comply with the requirements of BS 4417: 1969 (IEC 146 : 1973), shall be of the thyristor controlled, automatic constant voltage type with current limiting facilities.

The whole of the charging equipment shall be contained in a ventilated steel cubicle. The charger cubicles shall normally be mounted immediately adjacent to the DC distribution panel to form a board and shall be of matching design, colour and appearance, both with it and the substation control and relay panels.

The automatic charger shall maintain the batteries normally floating so that no discharge occurs under normal loading and the batteries remain fully charged. Chargers may be designed for operation from either 3 phase or single phase AC auxiliary supplies with nominal voltages of 415/240V and shall maintain the float charge automatically irrespective of variations in the voltage of the AC supply within specified limits.

The automatic float charger output voltage shall not vary by more than plus or minus 4% of the nominal float charge value, or exceed a maximum of 130V when connected to the load and operating under any combination of the following conditions:

a) Frequency variation 49.5/50 Hz
b) Rated input AC voltage variation plus or minus 6%
c) Output between 0 and 100% of rating

The output voltage regulator shall be adjustable and shall be so designed that special tools are required for such adjustment.

The rating of the charger on float charge shall be equal to the normal battery standing load plus the recommended finishing charge rate for the battery of the normal standing load.

A boost charger shall also be provided to recharge the battery after a heavy discharge. The voltage/current characteristics of the boost charger shall have a tapering characteristic in order to minimise gassing during the finishing period of a conditioning charge.

When a battery is being charged, it shall be disconnected from DC bus bars. It shall only be possible to boost charge one battery at a time.

At normal rated input voltage and frequency the boost charger output shall be not less than its specified rating at any battery voltage within the range 110/130V or such other range as is approved.

The maximum voltage of the boost charger when delivering the recommended finishing charge shall be not less than 1.8V per cell.

Each charger shall be provided with the following instrumentation, indication and alarm facilities:

- Red/Green-on/off indicating lamps for the incoming AC supply
- Voltmeter – input voltage

- Voltmeter – output voltage with low voltage alarm contact
- Ammeter – output current
- Alarm – charger fail
- Amber Indication Lamp – Boost charge

The minimum requirement for the charger fail device shall be the detection of AC supply voltage failure. The voltage failure detecting device shall not operate on switching surges or transient loss of voltage due to faults on the power system.

Suitable blocking diodes shall be provided to prevent the battery voltage being supplied to charger equipment so that in the event of DC output failure from charger or reduced DC output voltage from a charger failure indication/alarm is not prevented.

In addition each charger shall be equipped with a switchfuse for the incoming AC supply and either an off load isolator or disconnecting links for the DC output. Two sets of disconnecting links shall be fitted to the boost charger, one for each battery.

Each charger shall also be capable of sustaining without damage to itself, a continuous permanent short circuit across its output terminations.

8.8 D.C. SWITCHBOARDS

The switchboard shall comply with the requirements of BS5486 & (IEC 439).

Distribution panels shall be mounted adjacent to the charger control panel and shall be of the cubicle type complying with the general requirements of this specification for cubicle type control panels.

Distribution panels shall incorporate double-pole switches and fuses for each of the outgoing DC circuits and double pole isolators for the incoming DC supply from the charger and for battery connections. The panel shall be provided with a voltmeter and centre zero ammeter on each incoming battery circuit.

Battery earth fault detecting relay which will centre tap earth the 100V system via a high resistance and battery low voltage alarm device shall be incorporated in the distribution panel.

Each device shall have three alarm contacts, one for local visual annunciation, one for the station control panel alarm indication and one for audible alarm. The battery low voltage alarm device shall be adjustable over an approved range. No volt relays will not be accepted for this device. Double pole changeover contactors shall be included in each incoming battery circuit to obtain the charging conditions specified in Clause 8.2. The contactors shall be both electrically and mechanically interlocked so that it is not possible for both batteries to be connected to the boost charger at the same time. Both batteries shall be automatically reconnected to the main DC distribution board on failure of either the boost or auto charger.

An over voltage detection equipment to give local and remote alarm when the D.C. voltage rises more than 5% above the normal automatic float charge. A time delay shall be incorporated to prevent operation when a battery with high open circuit voltage is switched from the boost to float condition.

Connections between the batteries and the distribution cubicle shall be made in solid copper rod or PVC insulated cables as required. Cable laid in runs where it may be subject to damage shall be protected by wire armouring and be sheathed overall.

Copper rod connections shall enter the cubicle near the top through suitably insulated plates and shall be so arranged within the cubicle that they do not impede the making of connection to distribution circuits.

Cable boxes shall be provided as appropriate for all incoming and outgoing circuits of the distribution switchboard and associated battery chargers. Each circuit shall be suitably labelled at the front of the panel and at the cable termination where the terminals shall be additionally identified.

Charging and distribution switchboards shall be provided with copper earthing strip in accordance with the requirement of Section 9 of this Specification.

9.0 EARTHING

9.1 GENERAL

Transformer neutrals shall be earthed as detailed below:

132KV neutrals	solidly earthed
33KV neutrals of transformer	Resistance earthed
415V neutrals	solidly earthed

Earthing electrodes and connections at each substation shall be in accordance with the recommendations in the BS Code of Practice CP 1013:1965. Earthing electrodes buried in the ground in suitable locations as close to the electrical plant as is feasible. The groups of earthing electrodes shall be interconnected with each other and connected via links.

The earthing system specified in OES 11 shall be provided and it shall incorporate the relevant requirements specified in this section.

All equipment necessary for a complete earthing system shall be provided including electrode chambers and covers, positioning of all earthed electrodes, installation and connection of all earthing conductors and testing of each earth point.

A detailed layout for the earthing system shall be submitted.

A main hard drawn high conductivity earth bar, not less than 300 sq.mm shall be provided to which the frames of all electrical apparatus and structural steel work shall be connected by branches of the same cross sectional area to this main bar or to subsidiary bars running to a group of equipment. All overhead line earthwire terminations at substation, post insulator bases, sealing end bases, neutral current transformers, power transformers, surge arrestor bases, HF coupling equipment shall be connected to the earthing system which shall also be extended to indoor switchgear, control relay and ancillary equipment.

The ohmic resistance of the earthing system to the general mass of earth shall be less than 1 Ohm.

9.2 EARTHING POINTS

A minimum of six earthing points at the substation shall be provided. The number of rods and earthing points shall be based on the substation and earthing system layout, the resistance between any point on the earthing system and the related earthing electrodes and the overall resistance of the system to the general mass of the earth.

Each earthing electrode shall consist as required of clusters of 15mm diameter copper rods, each at least 3.5 meters long driven into undisturbed soil. The spacing between each electrode shall not be less than the length of the rod. Each rod shall be complete with approved non-ferrous clamps for the connections of earthing

conductors and with a hardened steel tip and cap for driving by means of a power hammer. Each cluster or group of electrodes shall comprise at least four electrodes.

Electrode link chambers and concrete covers shall be provided to facilitate ready inspection of the connection. Locations for the electrode chambers and the interconnection arrangement shall be based on the result of the earth tests.

The resistance between any point of each system and the related earthing electrode shall not exceed one ohms and the overall resistance between the earthing installation and the general body of the earth shall be less than one ohm under any climatic conditions.

9.3 EARTHING CONDUCTORS

Conductors for interconnection between the electrode in any group and between groups shall have a cross sectional area of 300 sq.mm and there shall be at least two such connections to each electrode group.

Conductors for connection between the electrode groups and station earthing main bars shall have a cross sectional area of 300 sq.mm.

Earthing conductors shall be of annealed high conductivity copper and shall be stranded in accordance with IEC . They shall be protected with an extruded PVC sheath of 1000 volts grade.

Where due to site earth resistivity conditions it is found necessary for electrode groups to be driven in locations remote from the substation earth bar system insulated earthing conductors shall be employed.

Earthing conductors shall be buried directly in the ground between the electrode chambers and buildings. Inside buildings they shall be cleated to walls and ceilings or fixed to cable racks or laid in the cable trenches as convenient.

9.4 EARTH BARS

Main earth bars shall comprise annealed tinned copper strip approximately 50mm by 6mm with a cross sectional area at least 300 sqmm interconnected at suitable points buried in the ground or supplied on building structures, cable trench walls etc. by means of brass clamps speaced at not more than 1.25 metre centres.

Branch connections from the main earth bars shall comprise annealed copper strip, the size of which shall be as detailed below, connected to all equipment containing or supporting electrical apparatus, earth batteries etc.

Substation fencing shall be provided with an independent earthing system less than 4 ohms.

The size of copper earthing strip or conductor to the various items of equipment shall not be less than the following and shall be adequate for the maximum earth current likely to be encountered:

EQUIPMENT	MINIMUM
132 surge arrestors, switchgear, transformers, systems neutral points etc.	300 sq.mm
33KV switchgear, transformers, steel structures, overhead line earth wire, terminations etc.	200 sq.mm
Control and relay panels etc.	100 sq.mm

Structure and supports forming a 3 phase set may be earthed in groups using a separate branch connection to each time of the group with a single subsidiary connection to the main earth bar. High frequency coupling equipment shall be earthed by separate connections taken direct to earth electrodes.

Earth connections to 132KV surge arrestors, switchgear, transformer neutral points and earthing resistors shall be made in 50mm by 6mm copper section direct to groups of earth rods and interconnected to the remainder of the earth systems.

Capacitor voltage transformers and surge arresters shall be connected to a single earth rod, driven to a depth of not less than 5m in addition to earth grid, in order to provide a low reactance path for high frequency signals.

Isolator and earthing switch operating mechanisms and circuit breaker control boxes not integral with circuit breakers shall be connected to the earth system by a branch entirely seperate from the employed for earthing the isolator, earthing switch or circuit breaker structure.

Such branches shall be connected to a ground mat which shall be provided beneath the position where an operator will stand.

The fences shall be earthed seperately from the electrical plant. The fence shall be electrically continuous at all points. This shall be ensured by bonding between the fence sections by minimum 100 sq.mm copper conductor.

The gates shall be bonded to the fixed sections by means of flexible copper jumpers of not less than 100 sq.mm.

The fence shall be earthed through earth rod electrodes, with at least one rod for every 20 metres of fence length.

9.5 EARTHING CONDUCTOR CONNECTIONS

Connections between the main earthing conductors and the main earth bars shall be made with lugs compressed onto the 300 mm2 copper strand. The lugs shall then be tinned and rivetted to the main earth bars.

Stranded earthing conductors shall be in the one continuous length and straight through jointing is prohibited.

Connections to plant and equipment shall be made using the earthing terminals specified in the contract.

Joints in earthing strip shall have the surface cleaned and tinned and shall be rivetted with copper rivets (not less than four 3mm rivets per joint) and soldered.

Non corrosive flux shall be used in all soldered joints.

Alternative approved methods employing chemical welding or high compression joints or clamps are acceptable

9.6 ANTI CORROSION PROTECTION

Earth conductors laid in exposed positions outdoors or buried in ground with is chemically corrosive shall be painted with two coats of bitumastic paint after installation and before covering. Earth conductors run inside buildings battery rooms etc. shall be painted with two coats of anti corrosive paint during erection.

9.7 FIXING DETAILS

All fixing botls, foundation bolts, screws, saddles, clips, jointing material and any other components required for fixing and mounting the earthing conductors and for connection of any equipment thereto shall be provided.

10.0 FIRE FIGHTING EQUIPMENT

10.1 SCOPE

The fire protection shall be provided as follows:

1 x 50 KG dry powder trolley mounted extinguishers	33KV switchgear room
2 x 10 KG dry powder wall mounting extinguishers	Control relay room
1 x 10 KG dry powder wall mounting extinguishers	Battery room
Water sprinklers	Transformer yard

10.2 PORTABLE FIRE EXTINGUISHERS

All apparatus shall be suitable for operation by one person alone and is to be easily recharged. The discharge is to be non corrosive and free of chemicals prone to give off toxic gases when heated.

The extinguishers shall be manufactured to BS 5423 : 1973.

The works shall include for the supply and installation of all wall brackets and fittings for small units and the provision of wheeled trolleys for units which cannot be carried easily.

Operating instructions shall be clearly printed on each unit.

Four "recharge" units shall be provided for each type and size of equipment.

10.3 TRANSFORMER FIRE PROTECTION

10.3.1 Water Spray Projector System

The system shall be designed to provide complete protection for the transformer employing quick water spray projectors, designed to produce extinguishment by forming a complete spray envelope over protected equipment causing emulsification of the oil and water discharged.

The system shall be designed to provide complete protection for the transformer employing quick water spray projectors, designed to produce extinguishment by forming a complete spray envelope over protected equipment causing emulsification of the oil and water discharged.

The system shall have a designed discharge rate of not less than 15 litres per m2 of protected surface area per minute and shall provide the complete spray coverage for a minimum period of 20 minutes.

The system shall as a minimum standard, comply to the latest edition of NFPA rules (No. 15.1 to 15.51) where appropriate.

All proprietary items of equipment shall be FOC approved of UL listed.

The system shall be of the dry type (i.e. all parts of the systems down stream from the deluge valves shall be empty when not in use). The water shall be supplied by fire protection pumps to the respective deluge valves which shall be normally held in the closed position by compressed air or hydraulic pressure in the detection system. Release of the pressure in the detection system shall cause immediate opening of the valve, starting the pump and flooding of the system.

The detection pressure shall be released by separate detectors suitably positioned within the zone protected.

The detector shall consist of a valve located in the air or hydraulic escape pipeline and locked in the closed position by a quartzoid bulb or fusible link designed to fail at a predetermined temperature, thus allowing the valve to open with consequent release of the pressure and operation of the deluge vale.

The detecion system shall be provided with automatic arrangements such that small pressure losses in the detection pipping will be automatically compensated for without manual operation of valves. Reliable air tight non-return valve and orifice plates shall be provided on the upstream side of such switches in order that the arrangements do not retard the operation of the system. Detector reservoir arrangements shall be designed to keep ''cut in/out" of the jacking compressor to a minimum.

The pumping arrangement for the system comprise two main pumps, one of which shall be coupled to an electric motor and the other to a diesel engine. Each of the pumps shall have characteristics such that they will operate satisfactorily in parallel. Either pump shall be capable of providing the flow and pressure required at every nozzle in any zone when the whole of that zone is in operation. The diesel engine shall be independent of mains electric supply for its automatic starting arrangements. The electric motor shall be suitable for use with a 415 V, 3 phase 50Hz supply.

Water in the supply main (upto the deluge valves) shall be kept under pressure by a small capacity jacking pump which shall only be capable of dealing with leakage from the system.

When the deluge valve operates, the jacking pump will be unable to maintain the pressure and the consequent drop in pressure shall activate two separate pressure switches which will start the main fire pumps simultaneously.

It is intended that the substations will normally be unattended. The protection system must therefore be designed in such a manner that it may be left without attention for long periods, yet remain reliable in all respects and without possibility of false actuation due to pressure losses. Due allowance shall be made during design for possible vibration of equipment protected. In addition to automatic topping up arrangements described above, the system shall be provided with full indication facilities. Automatic cutout arrangements shall be provided for main fire pumps, such that they shall be stopped when water supply becomes exhausted.

A twin fire services department inlet to BS 336 shall be incorporated into the system and shall be enclosed within a glass fronted box to the satisfaction of the relevant fire authority. Flow requirements of the system may make it desirable that two twin inlets be provided.

In addition to electrical alarms, local hydraulic alarm bells suitably indicated, shall be provided for each zone.

The system shall be suitably undercoated and painted after completion of the erection; water system in red, air systems in white and indication wiring conduits in black.

10.3.2 Alarm and Indication

The system shall as stated above, be provided with full indication facilities. Indicator panels and wiring between systems and panels, which shall be run in conduits shall be included in the supply. Alarm and indication panels shall be installed in the substation control room.

Water spray projector system (each zone).

The following indications shall be incorporated into the indicator panel which shall be both audible and visual:

a) **Fire**

To be operated by a pressure switch inserted into the detection pipework to react to loss of air pressure/ hydraulic pressure.

b) **Deluge Valve Open**

To be operated by a pressure switch inserted into the projector pipework immediately downstream of the deluge valve, set to react to a positive pressure.

c) **Low Detection Pressure**

To be operated by a pressure switch inserted into the detection pipework. This switch also initiate automatic cut in/out of the compressor.

d) **Deluge Valve Incorrectly Set**

To be operated by limit switches with contacts arranged to close down when isolating valves are not fully open, or drain or test valves are not fully closed.

e) **Reservoir Water Level Low**

To be operated by level switches, with contacts arranged to initiate alarm when the water level reaches below the normal level.

10.3.3 Drawings and Information Required For Approval

a) Approximate layout of the transformer showing position and target point for each detector and spray projector nozzle
b) Diagram of pipework and pumps for the complete water spray system.
c) Illustrated literature giving details of all proprietary items of equipment including detectors etc. Electrical schematic diagram.

11.0 LIGHTING AND SMALL POWER SYSTEM

11.1 GENERAL

The completed installation shall comply with OES 4. All materials shall comply with this Standard and shall be suitable for the climatic conditions at site.

All lamp fittings, plugs, sockets, circuit breakers and general accessories of the same size and types shall be similar and interchangeable throughout the installation.

All supports, connections, accessories and other items necessary for the satisfactory completion of the installation shall be provided.

11.2 ELECTRICITY SUPPLY

The 415/240V auxiliary supplies shall be obtained from the LV side of the 33/0.415 KV earthing transformers.

The LV supplies shall be 415/240 3 phase 4 wire 50Hz systems with the neutrals solidly earthed.

11.3 DESCRIPTION OF INSTALLATION

AC supplies for lighting small power, air conditioning units etc. shall be supplied from a main distribution board located in the control room.

The main distribution board shall be of the single busbar air insulated metal clad type incorporating air break manually operated switch fuse units for incoming circuits from each of the 33/0.415 KV transformers. The main distribution board shall incorporate a bus section isolator and this shall be interlocked with the incoming switch fuse units to ensure that it is not possible to parallel the two incoming 415V supplies. The main distribution shall include an automatic changeover contactor for the selection of the incomming supply from the main distribution board.

A separate sub distribution board shall be provided for essential services e.g. battery charger, emergency lighting, power line carrier, auxiliaries etc.

A no volt relay shall be fitted to include a ''LVAC supply fail" alarm when the supply to the sub distribution board is interrupted for more than 30 seconds.

Under AC failure conditions, the DC emergency lighting shall be automatically switched on.

A voltmeter shall be included on each bus section of the main distribution board and on the essential services sub board. Ammeters shall be provided in each incoming circuit to the main distribution board and to the essential services sub board.

Drawing No. 132KV/63 MVA/6 shows the general layout of the AC supplies.

11.4 DRAWINGS

Detailed working drawings for the lighting and power installations shall use a code to identify each light fitting and socket outlet.

The code shall comprise letters and figures to identify the following information:

a) The distribution board to which the fitting or socket outlet is connected.

b) Into which section (AC or DC) of the distribution board, the light fitting is connected.

c) The circuit number and phase of a particular section into which the fitting is connected.

d) The sequence of the fitting in the particular circuit.

11.5 TYPE OF SWITCH

Switch shall be rated for 5 Amps and shall be provided with an earth terminal.

Type L1

Switches for use in areas designated for surface installation shall be quick-make-quick-break fixed grid industrial types mounted in galvanised malleable iron boxes with protected dolly and arranged where necessary for multigang switching.

Type L2

Switches for use in areas designated for flush installation shall be micro-break types fixed to white plastic cover and mounted in PVC flush type box.

Type L3

Switches for external use shall be of the surface mounting 5 Amp quick-make-break pattern, industrial type housed in a cast iron galvanised weatherproof box, operated by means of a brass crutch handle.

Type L12 and L22

Identify two way versions of Type L1 and L2 respectively.

11.6 TYPES OF LIGHT FITTING

Each light fitting shall be manufacturer's nearest standard type to the type specified. Light fittings for interior and exterior use to be manufactured and tested in accordance with the appropriate code or standard and together with all components shall be suitable for service and operation in the tropical climate stated. Each fitting shall be complete with all lamp holders, control gear, internal wiring, fused terminal blocks, earth terminal and reflectors or diffusers as specified hereinafter. The design of each fitting shall be such that the ingress of dust, vermin and insects is prevented and where open type fittings are used it should not be possible for insects to become lodged therein. The control gear for fluorescent and discharge lamps shall incorporate power factor correction and interference suppresion capacitors and be suitable for use on a 240 volt 50 Hz system. Chokes shall be manufactured to restrict the third harmonic component to a minimum.

Internal connections shall comprise stranded conductors not less than 0.75mm2 covered with a heat resistant insulation such as silicone rubber or asbestos compound. All internal wiring shall be adequately cleated to the fitting chassis with an approved form of cleat.

The finish of fittings for interior use shall have a vitreous enamel, natural aluminium or galvanised finish according to the manufacturer's standard product.

The various types of lighting fittings which shall be supplied and installed are listed below:

a) Mercury Vapour Lamp

Mercury vapour lamp shall be provided for road lighting and car park. The lamp shall have non-ferrous cast alloy housing with hainged non-yellowing type bowl complete with optical system to give CIE cut off light distribution neoprene gasket heat baffles, porcelain lamp holder all suitable for 250 W high pressure power factor corrected mercury lamp (HPMV).

b) **Tungsten Lamp**

Bulkhead type fitting having a body cast from corrosion resistant LM 6 aluminium alloy with light control by means of a prismatic glass held firmly in position in a hinged glazing ring complete with porcelain type lamp holder for 240V 100 Watts tungsten lamp shall be provided at entrance and exist of substation building. Fitting shall be weather proof.

All fittings shall be completely weatherproof and sepcifically designed to withstand the high temperature imposed by this particular light source. The casings and reflector shall be manufactured from aluminium and shall be complete with armour glass front, suitably rated HRC fuse and heat resistant cables to a fixed terminal block.

c) **Fluorescent Lamp**

For normal and emergency lighting within the substation building the fittings shall be weather proof, fluorescent fittings, twin tube light, industrial type with glass diffuser.

The emergency fittings mounted near the escape doors shall have exit signs written both in Arabic and English.

d) **Sodium Vapour Lamps**

For the security lighting weather proof Sodium Vapour Lamps fittings shall be provided. The fittings shall be of cast aluminium housing with control gear and lamp holder and stirrup for mounting. The fitting shall be suitable for 400 watt Sodium Vapour Lamps.

The scope includes the supply and erection of all lamps and tubes necessary to complete the installation.

11.7 TYPE OF SOCKET OUTLET

The various types of socket and switch fused spur outlets to be supplied and installed shall comply with OES 4.

All sockets and spur outlets shall be mounted at 0.5 meters above floor level and are to have terminals adequate to receive 2-4 sq. mm conductors, with the exception of those for use with clocks which are to be mounted at 2 meters above floor level and have terminal capacity for 2 x 1.5 sq. mm.

Type S2

To comprise a one gang 2 Amp two pin socket outlet with galvanised iron base and baseplate suitable for use with synchronous electric clock. The necessary plug is to be provided with each socket.

Type S13

To comprise a one gang metal clad 13 Amp, 3 pin interlocked and shuttered surface mounted switch socket outlet with galvanised iron box to the requirements of the appropriate code or standard.

Type S23

To comprise a one gang metal clad, 13 Amp switched fused spur outlet with fuse manufactured to the appropriate code or standard suitable for surface mounting with aluminium box.

Type S100

To comprise a one gang weatherproof galvanised iron clad 100 Amp, heavy duty, 3 pole, 415V socket outlet with scrapping earth connection. A screwed dust cap and cable gland shall be included.

11.8 LIGHTING AND SOCKET REQUIREMENTS

The lighting installations shall be designed to give the illumination levels for the respective areas set out in the following schedule. The installations shall also meet the limiting glare index requirements as set out in the approved code. This schedule also gives proposals for the types of fittings to be used in each area, type of control to be employed, number of socket outlets and the type of mounting expected to be suitable for the respective areas.

The word "remote" under the heading Type of Control indicates that it is proposed that the lighting fittings be switched by the contractors controlled from ON/OFF push-button stations or time switches located at suitable positions in the area of the lighting circuit.

The word "local" indicates the lighting fittings shall be switched by 5 Amp single pole switches positioned in the area to be lighted.

The emergency lighting system shall be supplied from the 110 volt battery at the substation.

Emergency lighting shall be arranged to illuminate all exits and entrances, and provide some illumination in the switchgear rooms and in the control room. DC supplies for emergency lighting shall be obtained form the DC distribution board via an emergency lighting contactor in the event of failure of AC supplies.

A battery operated, self contained quartz clock shall be supplied and erected at a suitable location in the control room.

SCHEDULE OF REQUIREMENT

Area	Lighting Levels		Types Of Fitting		Type Of Mount.	Clock	Tyep Of Control & Switch	Socket Outlet
	Lux	Index	Main	Emerg				
Substation								
Control Room	400	19	F	T	C	1	L1/local	S2 2/room
Switchgear Room	100	–	F	T	W	–	-ditto-	S13 4/room
Offices	400	19	F	T	C	–	-ditto-	S13 4/room
Toilets	100	–	F	–	C	–	-ditto-	S23 1/room
Stores	200	–	F	T	C	–	-ditto-	S13 4/room
Battery Room	100	–	F	T	C	–	-ditto-	S13 2/room
Outdoor Yard	100	–	F	T	Flood Lights	–	-ditto-	S100
External Area								
Road ways	10	–	M	–	8 Pole		Remote	
Car Park	10	–	M	–	8 Pole		Remote	
Fence	10	–	M	Flood Height	light to suit	Remote		

Note

"C" – denotes "CEILING MOUNTING"
"W" – denotes "WALL MOUNTING"
"F" – denotes "FLUORESCENT LAMP"
"T" – denotes "TUNGSTEN FILAMENT LAMP"
"M" – denotes "HPMV LAMP"

11.9 CONDUIT AND FITTINGS

Conduit and fittings shall conform to OES 4 Clause 3.12.

11.10 INTERIOR AND EXTERIOR INSTALLATIONS

Installations shall be in accordance with OES 4.

11.11 EARTHING AND BONDING

Earthing and bonding of electrical installations in the substation building shall be in accordance with OES 4.

11.12 ERECTION OF LIGHT FITTINGS

Fittings shall be mounted direct on ceiling or walls. Where fittings are to be suspended, rod type suspension units shall be employed, with ball joints between the rods and ceiling plates.

Final connection to all suspended lighting fittings shall be with the fire resistant flexible silicon rubber cable terminated in porcelain clad connectors in the ceiling or junction box which shall also terminate the main circuit cable. The cable length shallbe such that the rod suspension supports the full weight of the lighting fittings.

Where fittings are mounted direct on walls or ceilings the main cable tail may be wired into the fitting terminal block. Where terminal blocks do not exist flexible heat resistance cable shall be used to connect to a separate junction box.

11.13 DISTRIBUTION BOARDS

a) Types and Breaking Capacity

Distribution boards and sub distribution boards shall be of the single busbar air insulated metal clad type incorporating air break manually operated switch fuse units or miniature circuit breakers (MCB) or fuses.

All switchboards shall be suitably rated for a prospective rupturing capacity of 31.5KA at 415 volts.

b) Busbars

Switchboards and fuseboards shall each include 3 phase busbars and one neutral busbar of high conductivity copper supported to withstand all normal and fault condition stresses.

The neutral busbar shall have a rating not less than that of the associated phase busbars.

c) Construction

Each switchboard shall be constructed in accordance with OES 4. The switchboards shall be of a type which are readily extensible and shall be suitable for indoor or outdoor use as specified in a tropical climate.

Cubicle type switchboards shall be suitable for floor mounting with arrangements for bottom entry of cables. Provision must be included for gland plates so arranged that there can be no access by vermin and insects to the interior of the switchboard.

Distribution fuse or MCB boards shall be of the metal clad type with protective insulating barriers between the phases and between phase and neutral. Neutral connections for each circuit shall be made direct to the neutral busbar in each fuseboard via removable links. The metal casing of the fuseboards shall be provided with knock out or other approved cable entries for accommodation of the cable and cable glands, the number and size of such knock outs being such that the use ways can be used in any combination of single phase and 3 phase circuits.

A no volt relay shall be fitted to the essential services sub boards to indicate a "LVAC" fail alarm when the supplies to both busbar sections is interrupted for more than 30 seconds.

d) Switch Fuses

Each switch fuse unit shall be housed in a separate metal compartment and provided with a hinged metal door interlocked with the switch mechanism so that:

i) The door cannot be opened whilst the switch is closed.

ii) The door, on opening, automatically locks the switch in the "OFF" position. Facilities shall be incorporated to allow for the deliberate release of this interlock should for maintenance purposed, it be desired to observe the switch in operation.

An insulating barrier shall be fitted to segregate the fuses and neutral link from the switch and the connections of the later shall be effectively shielded by an inner screen when the compartment door has been opened to obtain access to the fuses.

The switch fuses may be either of the combination fuse switch type or of the type with the switch and fuse in separate units.

In either case, inter locking shall be provided to prevent access to the fuses until the associated switch is opened and provision shall be made for pad locking the switch in the "ON" and "OFF" positions.

The switch shall have a quick and quick break action independent of the speed at which handle is operated and shall be entirely suitable for switching the inductive loads associated with motor circuits.

e) Miniature Circuit Breakers

Circuit breakers shall be of the thermal/magnetic type to BS 3871 or equivalent with quick make and quick trip free mechanism which prevent the breaker being held in against overloads or faults.

Tripping arrangements shall be such as to ensure simultaneous opening of all phases. Arc extinction shall be by de-ionising arc chutes.

The dolly shall have three positions, "ON", "OFF" and "TRIPPED". To reset from the "TRIPPED" position the dolly shall first pass into the "OFF" position.

MCBs on the main switchboard shall have facilities for locking in the "OFF" position.

The rupturing capacity of the MCB shall not be less than that of the switchboard itself, or if this is not the case back up fuses must be included.

f) Contactors

Contactors for controlling supplies to the "ESSENTIAL SERVICES" switchboards shall be of the 3 phase type with neutral links.

The contactors shall be provided with electrical closing and hold-on-coils, the no-volt release being provided with a time delay feature adjustable between 0 and 30 seconds.

When in the "STANDBY SUPPLY" position, the contactors shall automatically revert to the "NORMAL SUPPLY" position as soon as such supply is restored.

The contactors shall be provided with an indicating lamp coloured amber to indicate when the contactors are in the standby position, and with clearly indicated "NORMAL" and "STANDBY" mechanical indications visible with the distribution board door in the closed position. It shall not be possible for incoming auxiliary supplies to be paralleled.

g) Fuses

Fuses shall be of the HRC cartridge type for operation at a prospective fault level of 31.5 KA and conforming to IEC 269. The mountings of the fuses shall be such that they can be readily withdrawn and replaced whilst the associated busbars and circuits are alive. Incoming circuits at switchboards and fuseboards shall not be provided with fuses, the circuits being protected in each case at the point of supply. Interconnector circuits with other 415 volt boards shall be provided with fuses at both boards.

h) Interlocks

In addition to the integral interlocks specified above to prevent access to the fuses until the assocaited switch is open, "MAIN DISTRIBUTION" switchboards shall be provided with mechanical key type interlocks of the "CASTELL" type in order to prevent the two normal incoming supplies being paralleled with interconnector circuits from other boards.

The interlocking arrangements shall be as follows:

a) The switches controlling the normal incoming supplies and the switchboard bus section switch shall be interlocked so that only two of these three can be closed at any one time.

b) The switch controlling the interconnectors with other boards shall be interlocked so that it can be closed only with the bus section switch and/or the switches controlling the normal incoming supplies open and vice versa, in order to prevent the interconnector being paralleled with either of the normal supplies.

i) Earthings

Earthings of metal of switchboard, switch fuse units and distribution boards shall be bonded together and connected to earth pit for substation building. Earthing connection shall be carried out in bare finished copper strip with main connections approximately 25 x 4mm but atleast 100mm2 and subsidiary connections of 2.5mm2.

j) **Oil Treatment Outlet**

The "Main Distribution" board shall include a suitably rated switch circuit for a three phase and neutral interlocked plug and socket. The interlock shall prevent withdrawal of the plug with the switch in the "ON" position. The socket shall be suitable for an outgoing flexible trailing cable to the oil treatment plant.

The plug shall be provided with a "SCRAPING EARTH" connection to the socket and means for connecting the cable earth screen/conductor to the plug cap.

The socket outlet shall be installed adjacent to each transformer.

11.14 SMALL POWER CABLES

The supply and installation of cables and wires shall generally be as specified in OES 4.

11.15 CABLE TRAYS

Cable trays where required shall be provided and they shall conform to OES 4.

11.16 TRUNKING

Trunking where required shall be provided and shall be in accordance with OES 4.

11.17 TELEPHONE SOCKET OUTLET

Telephone socket outlet shall be provided in the following places:

1) Control Relay Room
2) Office
3) 33KV Switchgear Room

12.0 AIR CONDITIONING AND VENTILATION

12.1 AIR CONDITIONING

Air conditioning of the following areas of substation building as per requirement shown below shall be provided:

Area	Condition to be maintained
1) Office, Control/Relay rooms power line carrier room, office room	25 plus or minus 1 Deg. C with 55 plus or minus relative humidity
2) 33KV Switchgear room	32 Deg. C

Detailed design calculations and plant details to be submitted for approval.

12.2 VENTILATION SYSTEMS

The following areas shall be mechanically ventilated to a minimum of 10 air changes per unit:

Toilet
Battery room

Supply panels shall consist of a sand trap, fresh air intake louvre, filter and fan section.

Air shall be extracted from each of the rooms by wall mounted extract fans discharging to atmsophere. Extract air volumes shall be 80% of the supply air volumes to maintain a positive pressure in these areas.

Extract ventilation shall be provided in the toilet by surface mounted centrifugal extractors. Each toilet extract unit shll incorporate two fans arranged for automatic changeover in the event of failure.

12.3 INTERNAL NOISE LEVELS

The maximum acceptable noise levels in all areas shall have a noise rating (NR) of 40.

All plant and equipment used in the works when operating at the design conditions stated on the drawings shall not result in NR criteria in excess of those shown above.

Where attenuation devices are added into systems to ensure the required room NR levels, the additional resistance to airflow produced by such devices shall be included as part of the system resistance when evaluating fan performance.

12.4 VIBRATION

All vibration producing equipment shall be isolated from the substation building by means of anti-vibration and noise isolators. The degree of isolation shall be such that the noise criteria specified above are not exceeded and that no part of the building structure is subjected to vibration amplitudes in excess of the following values:

Frequency (HERTZ)	2	5	10	20	50
Amplitude (MM)	0.2	0.07	0.02	0.008	0.002

12.5 RADIO INTERFERENCE SUPPRESSION

All plant and apparatus, including such items as contactors, starters, relays and the like where the normal operation is such that interruption of low frequency or direct current occur, shall be fitted with means of suppressing all interference frequencies caused.

The standard of interference suppression shall be in accordance with the current edition of BS 800. Details of the equipment and methods to be used in quantitive assessment of the level of radio interference shall be as specified in BS 727.

For guidance in the installation of electrical equipment to meet the foregoing standards, reference shall be made to BS Code of Practice CP 1006 "General Aspects of Radio Interference Suppression" which deals with interference caused by electrical apparatus and installations.

13.0 CABLES

13.1 GENERAL

All cables included in the offer shall be suitable in all respects for the site conditions specified in OES 11.

The voltage and other basic characteristics of the systems to which the cables will be connected shall be as specified in OES 4.

Cables shall be suitable for operation at the guaranteed maximum sustained current ratings under the worst climatic conditions to be expected at the site.

Cables shall be capable of withstanding for a period of 3.0 (three) seconds the maximum fault currents specified in OES 11.

For the purpose of calculating cable current ratings, the ground temperature at 1 metre depth of cover shall be taken as 35 Deg. C and the average thermal resistivity of the soil as 1.50 Deg. C m/w. The average maximum ambient air temperature shall be taken as 50 Deg. C.

13.2 CABLE SIZE

Size of cables shall be as follows:

a) 33KV XLPE copper cable between 63MVA transformer and 33KV switchboard – 1x630 sq.mm/phase copper conductor.

b) 33KV XLPE cables between 63MVA transformers and appropriate earthing transformers – 1 x 185sq.mm copper conductor.

c) 1000V XLPE cables between auxiliary earthing transformer and main distribution board – 4C x 300 sq.mm XLPE copper conductor.

d) 1000V cables between main distribution board and sub-board for essential services – 4C x 70mm XLPE/ PVC/SWA/PVC copper conductor.

13.3 TYPE APPROVAL

Cables and accessories for voltages of 33KV and above shall have satisfactorily passed type approval test equal to those required by the International Electro Technical Commission and details of the cable designs shall be given.

13.4 OUTDER COVERINGS

Unless otherwise specified, the cable outer coverings shall be provided in the form of an extruded continuous black PVC sheath which shall be type Table I of BS 6746. As a protection against termite attack, the outer coverings shall contain an evenly dispersed mixture of aldrin and dieldrin in the ratio of 0.25% aldirn and 0.25% dieldrin by weight of PVC, or other suitable deterrent which shall be stated.

The PVC outer coverings for cables designed for voltages of 33KV and above must have been subjected to abrasion, penetration and saline bath tests during the type approval programme of tests.

13.5 CABLE DRUMS

Cable drums shall be non-returnable and shall be made of timber, pressure impregnated against fungal and insect attack. Alternatively, cable drums may be made of steel suitably protected against corrosion. They shall be lagged with closely fitting battens.

Each cable drum shall bear a distinguishing number on the outside of one flange. Particulars of the cable i.e. voltage, conductor size, number of cores, types, length, gross and net weights shall also be clearly shown on one flange. The direction of rolling shall be indicated by an arrow on both flanges. Cable ends shall be sealed at the ends by approved means at the factory after testing.

13.6 JOINTING ACCESSORIES

Cables shall be installed in maximum possible lengths and straight through jointing between shorter lengths, will not be permitted without the prior approval.

Jointing accessories shall include all necessary internal and external fittings, insulating materials and sundries, metal glands, armour clamps, earth bonding, terminals.

Mechanical glands for the termination of elastometric or thermoplastic insulated cables into straight through joints and termination accessories shall meet the requirements of BS 6121 or equivalent IEC standard and shall be correctly designed for the termination of galvanised steel wire or aluminium armour.

The gland shall not only adequately secure the armour to provide efficient electrical continuity, but shall also provide a water tight seal between the over sheath and the inner extruded or taped bedding to prevent the ingress of moisture.

Glands shall project at least 25mm above the gland plate to avoid any condensation flowing into the cable crutch. All glands shall be fitted with a substantial earth bond terminal.

Sealing end porcelains shall be free from defects and thoroughly vitrified so that the glaze is not depended upon for insulation. The glaze shall be smooth and hard, completely cover all exposed parts of the porcelain and for outdoor types shall be a uniform shade of brown.

Porcelain must not engage directly with hard metals and where necessary, gaskets shall be interposed between the porcelain and the fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

Outdoor sealing ends and fittings shall be unaffected by atmospheric conditions, proximity to the coast, fumes, ozone, acids, alkalis, dust or rapid changes of air temperature between 15 Deg. C and 65 Deg. C under working conditions.

All outdoor type sealing ends shall be provided with adjustable arcing horns.

A brass device shall be provided at the base of each sealing end to enable the insulator to be short circuited.

Sealing end supporting shall be constructed of galvanised steel and their design shall be approved when required for testing purposes.

13.7 CABLE JOINTING INSTRUCTIONS

Copies of the instructions for the jointing of each type of cable terminating and jointing accessories shall be submitted for approval before any work is commenced at site. Further copies of the instructions shall be bound into the Operating and Maintenance Instructions to be supplied at the completion of the contract.

13.8 SCHEMATICS AND ROUTING DIAGRAM

The Contractor shall be required to prepare a comprehensive power and multicore cable schematic and routing diagram, indicating the positions of joints, earthing equipment and terminations of all cables for approval.

13.9 33 KV SINGLE CORE XLPE CABLES

a) General

The 33KV cables shall be constructed in accordance with and conform to IEC Publication 502-1 subject to specific requirements detailed below.

b) Conductor

Cable conductors shall comprise stranded bare clean smooth annealed copper wires having a conductivity not less than 100% international standard. The surface of the individual strands shall be smooth and clean before applying insulation. The conductor shall comply with BS 6360 or IEC Publication 228.

c) Conductor Shield

The stranded conductor shall be shielded with an extruded semi-conducting layer before insulation is applied.

d) Insulation

The insulation shall be cross linked polyethylene meeting the following basic requirements:

– Normal operating temperature	90 Deg. C
– Permitted over load temperature	130 Deg. C
– Short circuit temperature	250 Deg. C
– Chemical resistance	High
– Moisture resistance	High
– Thermal resistivity	Low
– Fire resistance	Good
– Minimum average insulation thickness for 33 KV cable	9mm
– Minimum average insulation thickness for 33KV cable	9mm

The insulation thickness and dielectric strength shall be adequate and suitable in all respects for the highest system voltage of 36KV continuously, 33KV system neutral being earthed through 19.0 Ohm resistance via earthing transformer.

e) Insulation Shield

Individual core insulation shall be shielded by a layer of semi-conducting material applied directly over the insulation.

f) Metallic Layer

The semi-conducting insulation shield shall be covered by a bare copper shielding tape applied with a lap. The shielding tape shall be further supplemented by high conductvity copper wires in accordance with BS 6360 or IEC Publication 228 to meet the earth fault current specified and shall be capable of carrying the fault current for 3 secs and its final temperature shall not exceed 250 Deg. C.

g) Sheath

Sheath shall be extruded PVC complying with BS 6746 Table 1 Type 9.

h) Bedding

Over the sheath shall be applied a bedding fabric tape.

i) Armour

Armouring shall consist of single layer of aluminium strips applied over the bedding combined screen/ armour rating of these conductors shall be 25KA for 3 second.

j) Overall Serving

The overall serving shall consist of extruded PVC over the armour. The serving material to be Type 9 Table 1 of BSS 6746.

Cable size, manufacturer's name shall be embossed on the PVC serving. The PVC shall be fire retardant and termite resistance. Also, should be embossed on the PVC serving:

"PROPERTY OF MEW, OMAN"

k) Jointing Accessories

Jointing accessories for stranded copper conductor cables shall be designed for indentation or compression ferrules.

13.10 PVC INSULATED POWER AND CONTROL CABLES

a) General

This specification is for (A), single core and multi core power cables with conductors of stranded copper wires, and (B) control cables with stranded copper conductors. All cables shall be PVC insulated, PVC sheathed, galvanised steel wire armoured or aluminium armoured, and PVC sheathed overall. The PVC shall be Type 5 Table 1 of BS 6746.

b) Design

PVC insulated cable designs shall meet the requirements of the IEC or of BS 6346 – PVC insulated cables for electricity supply (steel wire of aluminium armour) upto 16 sq.mm or BS 6004 – PVC insulated cables (non armoured) for electric power and lighting.

c) Conductors

i) Except where otherwise specified, stranded copper conductors shall be untinned and comply with IEC or BS 6360. Single strand conductors shall not be permitted.

ii) Conductors for control cables shall be of copper and have a cross sectional area of 2.5 Sq. mm made up of 7/0.67 mm strands. Copper conductors shall meet the requirements of IEC or BS 6360. A minimum of 10% spare cores shall be available generally on all multicore control cables.

d) Fillers

Where fillers are necessary to make a circular compact PVC insulated cable, they shall be of PVC. Textile and other hygroscopic materials are not permitted.

e) Cores Identification and Laying Up

The cores of all cables shall be identified in accordance with Clause 7 of BS 6346. Multicore control cables shall contain one of the following standard numbers of cores:

4,7,12,19,27,37 and 48. When numerals are used, they shall be printed in black on the white core insulation at intervals not greater than 75mm throughout the length of the core. The print shall be permanent and not easily removed.

f) Voltage Identification

a) The PVC outersheath of power cables shall be embossed ''ELECTRIC CABLES" followed by the voltage in accordance with Clause 14.2 of BS 6346.

b) The PVC outersheath of control cables shall be embossed with the legend ''ELECTRIC LV CONTROL CABLE". The letters shall be raised and consist of upright block characters in accordance with the requirmenets of BS 6346.

In addition, all 600/1000V armoured cables shall be further identified by a varnished yellow paper, cellulose acetate or similar tape, bearing the letter ''LV" at intervals not greater than 100mm, applied immediately over the wire. The dimensions of the tape and marking shall comply with BS 6346.

g) Jointing Accessories

a) Jointing accessories for stranded copper conductors shall be designed for compression type conductor jointing ferrules.

b) The straight through jointing of short lengths of multicore control cables is not permitted.

13.11 TELEPHONE TYPE CABLES

a) Design

Telephone type multipair cables shall have tinned copper conductors insulated with PVC, armoured and shall be sheathed overall with PVC. They shall be suitable for internal and external use in a tropical climate five pair cables shall be used.

b) Conductor

Each conductor shall consist of a single tinned annealed copper wire, to BS 6360/1969 or IEC Stranded 228 and shall have a nomianl diameter of 0.9mm. The DC resistance per km of each conductor in the finished cable at 20 Deg. C shall not exceed 29.67 Ohms.

c) Insulation

The conductor insulation shall be of extruded PVC type 2 in accordance with BS 6746/1976 and shall have a radial thickness of 0.30mm plus or minus 0.1mm. the insulation thickness shall be determined in accordance with Clause 18 of BS 6346/1969.

d) Identification of Cores

The cable shall be made with twin twisted pairs. Cores shall be clearly colour identified.

e) Twining and Laying UP

The insulated conductors shall be uniformly twisted together to form a pair and the requisite number of pairs laid up to form a compact and symmetrical cable.

f) Fillers

Fillers are not required.

g) Binders

A polyethylene terephthalate (PTP) tape have a thickness of not less than 0.013mm shall be applied over the laid up cores with a 50% overlap.

h) Bedding and Armour

Cables shall be provided with an armour bedding of extruded black PVC, Type TMI or 6 compound in accordance with BS 6746/1976. The armour shall consist of one layer of galvanised steel wires complying with requirements of BS 1442. The thickness of the bedding shall be 1.0mm and the wire diameter 0.9mm.

i) Oversheath

The outer protective covering of the cables shall consist of an extruded PVC sheath in accordance with Clause 4.11.4. The PVC compound shall be Type TMI and coloured black in accordance with BS 6746/ 1976. The sheath radial thickness shall be 1.4mm and shall be determined in accordance with Clause 19 of BS 6346/1969.

j) Identification of Manufacturer

The PVC oversheath shall be embossed with the name of the manufacturer and year of manufacture followed by:

ELECTRIC CABLE – 100V

Embossing shall comply with Clause 14.2 of BS 6346/1969.

k) Cable Lengths

The cables shall be supplied in drum lengths of not less than 50m unless shorter lengths are specified or are required to complete a specific item of work.

l) Jointing and Terminating Accessories

Straight through jointing accessories for telephone type cables shall be designed for the accommodation of soldered or crimpted ferrules.

All jointing and terminating accessory designs for use with telephone type cables shall be submitted to the engineer for written approval before use.

13.12 CABLE INSTALALTION AND EARTHING

General

This section covers the installation of all cables described in the specification together with the erection of their jointing and terminating accessories. It also include the bonding and earthing of multicore and single core cables.

All cables laid inside substation boundary wall shall be in concrete trenches in trays with suitable earthing removable covers. Concrete trenches with trays and removable covers shall be provided within the substation boundary for future 33KV outgoing feeders.

13.13 ERECTION ON STEEL WORK

a) Supports and Racks

Cable supports and racks together with fixing clamps, bolts, nuts and screws for outdoor and indoor installtion shall be of hot dip galvanised steel.

Cable support and rack designs shall be submitted for approval before manufacture and erection.

Ten percent (10%) spare ways are to be provided on cable racks to allow the installation of future cables.

Multicore cable shall be clamped to the racks with smooth finish split packing pieces or cleats with bores of the correct size for the cable diameters.

The cleats shall be of silicon aluminium, glass filled nylon or other tough non-hygroscopic material. Single core cables shall be erected in close trefoil 3 phase groups in separate non-magnetic clamps.

All cable supports, racks, cleats, trays and sunshields together with all necessary steel work and fixing materials shall be provided and erected.

b) Erection of Supports

Rawl bolts shall normally be used for the fixing of supports and associated steel work to masonry.

The fixing of cable supports and associated steel work to building structural steel work, is to be carried out with bolted clamps. Weld gun stud fixing will be allowed subject to the approval site but the drilling of building structural steel work shall not be allowed.

c) Cable Trays

Cable trays shall be of perforated galvanised steel and shall be supported on steel work or masonry as required.

d) Erection on Racks

Details of the spacings between supporting clamps proposed by the contractor for cables having a conductor size greater than 125 sq. mm shall be stated.

The distance between rack supports for smaller power and for wire armoured multicore control cables shall be one metre for both horizontal and vertical runs.

13.14 PULLING INTO DUCTS AND TROUGHS

a) Cable Ducts

Cable ducts shall be supplied and installed. They will normally be in the form of PVC or spun concrete pipes having a nominal inside diameter at least 40mm greater than the cable diameter.

Ducts shall be completely embedded in concrete with a minimum 150mm thickness of concrete surrounding the ducts on all sides. Ducts shall be sealed at each end, with split teak wood plugs and bitumen or by other approved means to prevent the ingress of water and vermin.

b) Cable Troughs

Cable troughs shall be supplied and installed where required.

13.15 LAYING DIRECT IN THE GROUND

a) Excavation of Trenching

Laying of cable direct in the ground shall be done in accordance with OES 2. All other cables are to be laid to a depth in accordance with OES 2.

b) Cable Laying and Protection

Cables shall be laid and protected in accordance with OES 2.

c) Backfilling

Backfilling shall be done in accordance with OES 2.

d) Cable Installation Under Roads

Cables installed both along and under roads shall be protected by a concrete raft having a minimum thickness of 250mm and a width extending a minimum of 150mm beyond the sides of the cable trench.

The concrete raft shall be of a 6-3-1 or 8-4-1 mix and shall be laid immediately below the metalled surface of the road which shall then be reinstated.

13.16 CABLE PULLING

Cable pulling shall be carried out in accordance with OES 2.

13.17 JOINTING AND TERMINATING

The contractor shall be wholly responsible for the terminating into sealing ends or end boxes and the jointing of all cables erected under this contract. Cable sealing and jointing shall be in accordance with the best current practice and of first class workmanship.

Where cable screens are used as earth continuity conductors, glands shall have the necessary contract surface and bonding clamps to provide a low resistance path under fault conditions.

It is required that the PVC outer covering shall be subjected to periodic HV DC integrity tests. Joints and sealing end boxes shall be efficiently insulated and testing facilities shall be installed with the jointing accessories in an approved manner.

Where cables terminate into marshalling boxes, glanding off and termination shall be carried out. Straight through joints will not be permitted.

13.18 CABLE IDENTIFICATION

a) Core

The markers and identifying ferrules shall be provided.

b) Cable Route Markers

Where cables are buried in the ground, cable route markers shall be provided to indicate the location of the cables. All route markers shall be made of reinforced concrete or of other materials approved for the climatic conditions. Suitable materials for their manufacture or alternaitvely, the completely manufactured article should be assumed to be available locally.

c) **Cable Markers**

All power, control and telephone type cables shall be provided with identification markers at their terminations, and where the cables are not laid in the ground at points along the route at intervals of not more than 50 meters apart. Markers shall be made of durable material of an approved type.

d) **Core Markers**

Cores of solid dielectric and plastic insulated low voltage multicore control cables shall be identified with lettered and numbered marking ferrules which shall be made of a permanent material and shall be of an approved type.

e) **Cable Protection from Sun**

Where cables are installed and exposed direct solar radiation, sun shields of approved material and design shall be supplied and erected.

13.19

BONDING

a) **Pilot Cables**

The armour of pilot cables with extruded outersheaths shall be bonded together and connected to earth at all terminating and jointing accessories. Solid bonding connections shall also be made between adjacet multicore cables at terminations and joints.

b) **Power Cables**

All cables having an extruded outer covering shall be installed as an all insulated system.

Single core cable screens may either be solidly bonded or specially bonded (single point bonded or cross bonded).

Multicore cables shall be solidly bonded at each termination. Details of the proposed bonding system together with a schematic diagram shall be submitted.

c) **Copper Earthing Connectors**

Bonding leads shall be of sufficient cross sectional area to carry the maximum imposed short circuit level. Dimensions shall be submitted.

14.0 POWER LINE CARRIER

14.1 GENERAL

At present, there is a powr line carrier telephone system supplied and installed by Brown Boveri Co Ltd., Baden, Switzerland in the Ministry's 132KV system. This includes tele-protection channels for the 132KV lines and telecontrol for transmitting alarm signals.

The power line carrier system is to be enlarged and extended with such additional equipment as necessary to embrace the new substation in respect of both telephone, Tele-Protection and telecontrol channels.

Duplex carrier communication circuits equipped with transmit/receive high frequency units of the single side band amplitude modulated type shall be provided. The equipment shall be completely compatible with existing Brown Boveri equipment.

14.2 CARRIER FREQUENCY ALLOCATION

The design shall include where appropriate, frequency allocation plan to include all the 132 KV circuits shown as future in addition to circuits to be connected to the new substations.

All carrier frequency plans shall be agreed with the governing radio frequency licensing authority to ensure non interference with Air Traffic Control, Navigation Beacons etc.

14.3 HV LINE COUPLING

a) General

The high voltage transmission system is a three phase 50Hz system operating at a nominal 132KV voltage. The system's highest voltages are 10% in excess of the nominal voltage. The system is designed for impulse withstand levels of not less than 650 KVp.

b) Method of Coupling

Coupling of the carrier signals to the transmission line shall be intercircuit between phase of one circuit to phase of the other circuit. All line traps and mountings, coupling filter, conductor clams, HF connections, matching transformers, coupling capacitors and mounting pedestals, high frequency cables and glands required to complete the HF installation at each site shall be provided.

The drainage coils comply with IEC Publication 60. Coupling capacitors and coupling filters together with mounting framework and brackets shall be mounted on separate structures as shown in Drawing No. 132KV/63MVA/4 Line traps shall be mounted on coupling capacitors.

The capacitor shall have a rated capacitance of not less than 5000 pF at the working voltage of 132KV and an impulse withstand voltage of 650 KVP and meet the insulation and test voltage requirements of IEC recommendation for such devices (IEC Publication 358 – coupling capacitors and capacitor dividers).

c) Line Traps

The line traps shall have a rated continuous current of not less than 1600 amps and shall be capable of withstanding 31.5KA for a period of 3 seconds. The preferred value of coil inductance shall be 0.2 milli henries although other values will be considered. The line traps shall have a protective device which utilises nonlinear resistor type arrestors (IEC C99-1) and the discharge current shall be less than 10KA.

Line traps shall meet the tests recommended in IEC Publication 353 line traps, with regard to temperature rise, short time current ratings, protective discharge etc. and also the blocking capabilities of the line trap.

All line traps shall be provided with clearly visible rating plates which shall include: manufacturer's name, type, serial number, rated continuous current, rated short circuit current and blocking band etc.

Line trap mounting and connecting details shall be furnished.

d) Coupling Units

The high frequency coupling units together with mounting bracket shall be suitable for mounting on individual structures as shown in Drawing No. 132K/6301/4. The filters shall be suitable for outdoor use in a hot dusty climate and shall have weatherproof door seals together with breahter holes to avoid

condensation. The units shall have an earthing switch which should preferably be interlocked with the box door/lid such that the latter cannot be opened unless the earth switch is closed to earth the device. Clear indication of the ON/OFF position of this switch shall be indicated. The terminal on the filter which shall be connected directly to the substation earth shall be clearly designated.

The intercircuit coupling shall be such as to earth either of the coupling filters and continue with carrier transmissions on a phase to earth basis using the other filter.

The coupling device shall meet in full the safety and protection requirements of the IEC recommendations for such devices (IEC Publication 481 – coupling devices for power line carrier systems).

The tuning range of the coupling unit(s) shall be suitable for the HF carrier frequency allocations proposed and the composite loss over each range shall not be greater than 2db.

The line side and equipment side return losses shall be preferably less than 12db over the available band width of the filter. The line side impedance of the device shall be suitable for the range 200-400 ohms for phase to earth coupling whilst the nominal equipment side impedance shall be 75 ohms (unbalanced) or 150 ohms (balanced). The device shall be fitted with a rating plate which shall include manufacturer's name, type, serial number, peak power, bandwidth etc.

e) High Frequency Cable

High frequency cable suitable for connecting between the coupling filters and the indoor high frequency units shall be provided. The cable shall have a characteristic impedance of 75 ohms or 150 ohms depending upon the impedance of the coupling filters and the indoor equipment. The cable shall be PVC covered, steel wire armoured with a further outer sheath of PVC. Cross section of the cable showing the cosntruction and make-up shall be furnished together with electrical characteristics and test voltage.

14.4 POWER LINE CARRIER HIGH FREQUENCY UNITS

a) General

The type of equipment provided shall be of the single side band type constructed on modular bais with modules plugging into shelves.

The equipment shall be composed completely of solid state devices – no thermionic devices shall be permitted.

The design and performance requirements to be met by the power line carrier shall comply with IEC recommendation 49 and include the transmission of any combination of the following types of information:

a) Speech for telephone communication
b) Telephone signalling
c) Coded signals for supervisory/indications/telemetering
d) Tele-Protection
e) Teleprinter signalling

The equipment shall be suitable to operate at all times within the temepratures specified in OES 11.

Manufacturers shall state what precautions have been taken if the air conditioning fails and the equipment is subject to the environmental conditions specified in OES 11.

b) Technical Details

The equipment shall be of the single side band type with suppressed or reduced carrier transmission and each channel shall have a 4 KHz bandwidth. The sidebands for a duplex link may be adjacent, inverted or erect; the methods of transmission shall be mainly stated. Any limitations in paralleling their own or other manufacturer's equipment shall be stated with details of necessary frequency spacing.

Each 4 KHz band shall be capable of carrying varying amounts of communication traffic and should preferably be split as follows:

Speech	300 – 2400 Hz
VFT Channels	2400 – 4000 Hz
AGC	To be furnished
Telephone signalling	" "

The allowance shall be made in the subdivision of the 4 KHz band for future SCADA signalling at 600 bit/sec. A VF allocation plan showing the available channels in line with CCITT recommendations.

The virtual carrier frequency difference, in a pair of terminals, between the VF signal applied to the transmit end and that received at the receive end shall not exceed 2 Hz.

The nominal carrier frequency output power of the PLC terminal with 100% modulation shall be 10/15W and shall be measured at the line.

The nominal impedance at the carrier frequency output shall be 75 ohms (unbalanced) or 150 ohms (balanced) and provision shall be made for terminating the output in an appropriate dummy load. The return loss within the nominal carrier frequency band in the transmit direction shall be less than 10 db.

The maximum line attenuation possible to achieve a signal to noise ratio at all times greater than 26 db shall be stated. This figure should normally be 35 db or higher.

c) Telephone Channels

The two way telephone channels shall be suitable for 4 wire working at transit stations as determined by the requirements of the telephone scheme. However, circuits terminating at a station shall be suitable for connection to a 2 wire telephone exchange and 2/4 wire switching shall, therefore, be available as standard facility.

The preferred method of telephone signalling shall be to utilise the same VF signalling channel as the AGC in order to conserve above speech bandwidth. Other methods shall be clearly explained by tenderers.

Tenderers shall state clearly the relative four wire levels used for speech transmission and reception.

All speech and VF signal input and output circuits shall be balanced and have a nominal impedance of 600 ohms. The return loss within the effectively transmitted frequency bands shall be not less than 14 db.

Telephone facilities shall be provided between bays at each end of a link using a hand set together with an audible form of calling and also a lamp. Telephone channels shall not require the use of companders although it should be possible to add these in the future should there be a service requirement.

d) VF Channels

The input and output signal levels for the VF channels detailing the method and percentage of modulation under normal working together with a statement regarding the addition of VF channels in the future, shall be furnished.

e) Receivers

The method of automatic gain control proposed shall ensure that in the case of a 30 db change in carrier frequency signal level within the regulation range, the change in voice frequency receive levels of both speech and VF signals shall be less than 1 db.

A receive level low alarm shall be given some 6 db above a receiver fail alarm when the system has failed completely.

f) Service Conditions

The set noise generated within the terminals shall comply with IEC recommendations (Publication 495) as shall the cross talk attenuation between speech and VF signalling channels.

The type of modulation proposed for the speech and VF channels shall be stated.

The level of spurious emission shall be clearly stated in the Schedule of Guarantees together with the frequency response of the speech channel referred to 800 Hz and VF. Signalling channels referred to 3.0 Hz.

The equipment shall operate to its stated performance with a variation in power supply of -10% to + 5% and remain operational with an increase of power supply voltage of up to 20% of the nomainal value.

g) Voltage Withstand Requirements

The equipment shall be designed to withstand satisfactorily the following insulation tests:

2 KV AC RMS 50 Hz applied for one minute between:

a) i) All terminals (other than earth terminals) connected together and all metallic parts to be earthed in service.

ii) Between the output contact terminals with the contacts closed, and all the remaining terminals connected together.

iii) Between all electrical circuits of the equipment not intended to be connected together in service except where an earthed barrier exists between the circuits or where the circuits have mating contacts between them.

b) 1KV AC Rms 50 Hz applied for one minute across each output contact with the contact in the open

position. When the carrier frequency terminals are not isolated from earth they shall be capable of withstanding an impulse voltage of 3KV 1.2/50us applied between each terminal and earth.

The equipment shall not be subject to interference by the presence of electrical noise generated by isolator switching operations.

The bandwidth of such noise extends from 10 KHz to 1mHz and can peak to 1200 volts at the coaxial termination. Limiting diodes of the avalanche type should be provided at the HF cubicle terminals in order to limit this voltage to 400V peak to peak.

h) Test Facilities

The equipment shall have clearly designated test points on the modules on which adjustments are required together with test points on modules having nominal reference points. It shall be possible to mount a bay transmission measuring set or equivalent instrument in the sub rack to which the various test points can be connected to achieve wideband measurements. The equipment shall also have a variable level 800 Hz oscilator for injection of test tone when commissioning or maintenance work is performed on the bay.

The minimum requirement for alarm lamps shall be receive level low, receiver fail and transmitter fail and "clean" contacts shall be provided to initiate a remote carrier fail alarm.

i) Mechanical Details

The following conditions shall apply to the communications equipment mounting practice.

1) All terminal boards shall be mounted in accessible positions and, when in enclosed cubicles, are preferably to be inclined towards the door. Spacing of adjacent terminal boards shall be not less than 100mm and the bottom of each board shall be not less 200mm above the incoming cable gland plate.

   Terminals, mounting arrangements and method of termination shall be subject to the approval of the Engineer.

2) Each item of equipment in a group (i.e. a cubicle in a suite of cubicles) shall be individually fused and shall provide an alarm indication on loss of supply. One fused outlet from the main distribution bar shall feed an alarm type fuse panel mounted in the cubicle. This fuse panel shall supply individual items of equipment.

3) It shall be possible to remove/replace cards without damage and without interfering with the operation of the rest of the equipment or system; if necessary consideration should be given to switching off the supplies locally to a card to prevent inadvertent interference to the equipment or system when removing/placing a card.

4) Application of battery or earth via a test lamp to any external interface point or test point shall not lead to any component damage.

5) Power supply busbars in cubicles shall be carefully routed and each busbar shall be shrouded. It shall not be possible to inadvertently short busbars either between themselves or to earth.

6) Electronic equipment shall not use local internal batteries unless the approval of the Engineer has been obtained. Where approval is given, batteries used inside equipment shall be of the totally sealed, leak proof type.

7) Indication of blown fuses shall be clearly displaced by, for example, monitoring of the fuses:(s), or by the use of alarm-bead type. Circuits shall be grouped so that, following the operation of a protective device, the minimum practicable loss of facilities occurs.

The design, location and connections of fuse carriers and bases shall be such that they do not present a danger to an operator when replacing a fuse link with the equipment still connected to the supply and switched on.

8) Cubicles shall be complete with all necessary tag blocks, terminal plates and blocks and cable glanding facilities for small wiring and multicore cables. These items shall be located in an approved easily accessible position.

The design and construction of all cubicles, junction boxes etc. shall be such that cable terminations are arranged for either top or bottom cable entry for all cables.

The general design of cubicles shall be subject to approval, but they shall in general be of fabricated steel construction provided with shelves on which mounting plates can be accommodated. The height of cubicles or rackss shall not, unless otherwise approved, exceed 2.250 meters in height.

Cubicles shall be free standing and shall permit anchoring to the floor.

The arrangements and method of mounting of all apparatus in the cubicles shall be to the approval of the Engineer.

All ventilation holes and similar external apertures of enclosed equipment shall, wherever necessary, be fitted with a close mesh gauze as a protection against the entry of insects.

9) Hinged doors shall be provided and arranged to lie flat back and not restrict access to the appratus contained within the cubicle. Hinged doors shall be of the lift-off type unless there is wiring on the door, and shall be secured with integral handles and shall be flush fitting and sealed with a gasket of rubber or other approved material to prevent the ingress of dust. Provision shall be made for locking, with two keys provided for each lock. Cubicles and doors shall be structurally sound and not liable to distortion.

Where hinged gates are used for mounting equipment, they shall be provided with adequately protected wiring, of sufficient length and flexibility, to the equipment.

The lowest shelf or mounting plate shall not be less than 250 mm from floor level.

Alarm lamps shall be visible externally, with all doors closed.

10) Equipment provided in duplicate to function as working and standby units shall be arranged in separate cubicles and separate suites to allow either unit to be set up, powered, and tested independently of the other unit to ensure that the equipments are in working order to ensure the avoidance of common mode failure.

11) The environmental requirements of the Specification shall be taken into account when considering ventilation arrangements.

Heat dissipation of cubicle mounted equipment shall be kept as low as possible. For equipment

which will be supplied to this Specification, the average dissipation per cubicle shall be stated in the Tender.

Natural cooling is preferred. The approval of the Engineer must be obtained in all cases where it is intended to incorporate forced cooling.

Where the use of forced cooling has been approved, means shall be provided for indicating and alarming any significant reduction in air flow, and the equipment shall be so protected that no damage occurs due to failure of the forced cooling.

The full requirements of the performance specification shall be maintained until the protective device operates, and the period for which the equipment can remain in operation at maximum ambient temperature without forced cooling shall be stated. The effects on its subsequent performance shall so be stated. Air blown through equipment for cooling purposes shall first be passed through an efficient dust filter. Multi stage filters, arranged to permit individual filters to be removed for cleaning, are preferred.

12) The shelves which form a subrack shall be suitable for mounting in cubicles which do not require rear access. The cubicles shall be dust and vermin proof.

13) Inside the base of the cubicle there shall be a substantial earthing bar with studs to which the substation earth and all internal earthing shall be connected. No reliance shall be placed on the conductivity of metal to metal joints without the use of special connectors.

Connections between circuit and metal work shall only be made for reasons of safety and/or reduction of interference. Where such connections are made, they shall not be used as normal current carrying earth returns.

14) The cubicles shall be clearly labelled as to the bay designations and all alarm lamps and LEDs shall be clearly labelled. There shall be at least one external cubicle alarm illumination per internal PLC bay which will indicate the internal fault conditions when the cubicle doors are closed.

All modules and their shelf location shall be cross referenced and it is preferred that coded key slots are used in the edge connectors in order that modules cannot be plugged into the wrong shelf position.

The cubicles shall be clearly labelled as to the bay designations and all alarm lamps shall also be clearly labelled - Thesere shall be atleast one external cubicle lamp for PLC bay which will indicate internal fault condition when the cubicle doors are closed.

14.5 AUTOMATIC TELEPHONE SYSTEM

a) General

A telephone system shall be provided primarily to operate the HV system i.e. for switching and loading instructions, it will however also be used for maintenance and other purposes. The system shall provide duplex communications between stations.

b) HF PAX and Substation Termination Equipment

HF PAX shall be provided at the substation. The pax shall be register controlled exchanged of the semi electronic type with matrix or cross bar switching equipment and shall provide the following facilities:

a) 4 wire tandem switching
b) 4 wire long line extensions on pilot cables
c) Priority breaking and forced release for the distribution control engineer
d) Closed loop numbering plan

At the substation trunk termination equipment shall be provided for each carrier circuit together with a subscriber's telephone termination panel for the substation control room.

The substation control shall be able to break into the conversation of a transit call in an emergency if no other circuit is available to the central control centre and also be able to call the substation control telephone whether or not the hand set is off the cradle rest.

c) Closed Loop Numbering Scheme

The trunk numbering plan shall have three digit numbers which are the same for a given extension regardless from where the call is originated in the system. The first two digits shall designate the station and the third digit the particular subscriber extension within that station.

d) Telephone Signalling

The design of the telephone signalling system shall be chosen to best suit the future requirements of the central control scheme having regard to the most economic use of the frequency spectrum available for speech and telesignalling.

e) PAX Assembly and Mechanical Construction

The PAX (shall be of modular construction) and shall be housed in a well constructed dust proof cabinet. All equipment, apart from the switches the subscriber line relays shall be mounted on printed circuit cards which shall be plugged into shelves. The logic elements shall be largely built of integrated circuits with discreet components to interface between the relays and the integrated circuits.

f) Telephone Instruments

Telephone instruments equipped with cabling facilities (push buttons/and a priority push button) shall be provided.

Main distribution frames (MDF's) shall be provided with each PAX. These MDF's shall be housed in the PAX cubicle. Sufficient cubicles shall be provided initially to accommodate the ultimate number of lines.

The provision and termination of the interconnecting cables between the exchange and the MDF shall be included and also the termination of cabling external to the MDF which may be provided at a later date. External telephone extension shall be provided with fuses and protectors.

14.6 TECHNIAL SPECIFICATION FOR THE TELECONTROL EQUIPMENT

a) General

Telecontrol equipment shall be provided to transmit alarm signals from substation to the central control station.

b) Telecontrol Requirements

Four alarms (urgent, non-urgent and two spares) shall be transmitted from the substation to the central control station. The signalling shall be by means of frequency shift coded signals over one or mroe VF channels.

c) **Channel Allocations**

The VF allocation required for telecontrol shall be stated. The equipment shall be mounted on cubicles provided of rigid construction and shall be dust and vermin proof. The cubicle door(s) shall be lockable.

14.7 TECHNICAL SPECIFICATION FOR TELE-PROTECTION EQUIPMENT

a) **General**

Tele-Protection equipment shall be provided for 'direct' tripping, permissive tripping and block signalling on each 132KV line. The telesignalling channels for the Tele-Protection shall be routed on the PLC equipment.

b) **Protection Requirements**

For 132KV lines the following requirements shall be provided.

1) Permissive inter-tripping channels (both ways) initiated by the distance relays.
2) Block signalling channels (both ways) initiated by the directional earth fault relays.
3) Direct tripping channels (both ways) initiated by breaker fail relays.

c) **Tele-Protection Equipment Requirements**

1) **Direct Tripping**

The direct tripping equipment is required to effect the tripping of circuit breakers to disconnect faulted transformers and other main plaint from remote current in feeds, for acceleration of distance protection scheme and to relieve abnormal system loading conditions.

This type of Tele-Protection shall operate the remote circuit breaker tripping relays directly and hence shall have inherent security against mal-operations due to noise present in the bearer channel.

2) **Permissive Tripping**

The permissive tripping signals are required to operate remote circuit breaker trip relay in connection with distance protection relays.

3) **Blocking Signalling**

The blocking signals are required to prevent remote over reaching distance relays from operating for faults external to the protected line section to enable correct discrimination to be achieved.

d) **Technical Data**

The Tele-Protection equipment shall be of modular construction and preferably mounted in the power line carrier units and work satisfactorily under the service conditions detailed in OES 11.

Manufacturers shall clearly state the precautions taken in the design of their receivers to safeguard the trip output against the presence of noise in the VF channel, and show clearly the differences between the equipment used for 'direct, permissive' and 'blocking signalling.'

It shall not be possible to cause a trip output under any of the following conditions:

i) Removal of any printed circuit module in either transmitteror of receiver of a line including the PLC bays.

ii) Switching ON/OFF of the power supply to the tele-protection equipment.

iii) Switching ON/OFF of the power line carrier equipment at either end of the HV line.

iv) Shorting of the output of the Teleprotection transmitter or shorting of the input to the Teleprotection receiver.

v) Input signal level to the receiver below the receiver fail alarm thresh-hold.

vi) Operation of isolators in the local or far end switch yards.

vii) Equipment, fuse or channel failure.

The 'direct tripping' equipment shall be suitable for use with auto reclose schemes whereby the receiver trip output shall be maintained long enough to prevent the remote circuit breaker reclosing until the faulted plant is disconnected from the HV system. Details of how the equipment meets this type of requirement should be submitted.

The power supply to the Tele-Protection shall be taken directly from fused outlets on the distribution board and be separate from the PLC bay supply. Similarly each Tele-Protection equipment shall be separately fed from the 48 volts distribution board.

e) Signalling Conditions

The signalling speed of the channel shall be less than 30 milli seconds from the receipt of a trip command to the operation of the trip output at the receiving end, and the equipment shall work completely independently of the PLC speech and VFT channels used for other purposes.

The equipment shall perform on a frequency shift principle shall perform on a frequency shift principle and shall if super audio channels are employed, preferably employ a total bandwidth of not greater than 480 Hz. Each Tele-Protection channel shall be completely independent of the other except for the transmission channel. Facilities shall exist such that the following conditions apply to the alarm and output circuitry.

Guard	Operate	Signalling Faulty Alarm	Operational Output
Yes	No	No	No
No	Yes	No	Yes
Yes	Yes	Yes*	No
No	No	Yes*	No

* The alarm output shall not occur for at least two seconds however there shall not be any fleeting operational output prior to the alarm condition being given.

f) Alarm Facilities

The alarm output shall persist for a minimum period of 100 milli seconds and the operational output shall be sterilised until the alarm output condition is removed.

A separate low level alarm shall be given but not prevent operation when the input signal level drops by 6 db from normal. Manufacturers shall state the level at which the receiver will cease to function in line with the above table, this level shall be at least 10 db below normal.

Clean contacts shall be provided for remote alarming purposes suitable for operation at 110 volts DC.

g) Test Facilities

Test facilities shall exist whereby important operating values can be checked and a suitable test/normal switch arrangement shall be provided to show that the trip output circuitry is disconnected and functional tests can be safely performed on the equipment.

In the case of the direct tripping equipment the test/ normal switch shall be fitted with a lock and key and if more than one equipment is located in the same cubicle then each equipment shall have a different lock.

h) Protection Interface

The input/output interface to the protection equipment shall be by menas of reed relays and the input/ output rack wiring shall be carefully segregated from other shelf/cubicle wiring. The make contacts of the output relays shall be capable of making and carrying at least 250VA at 110V DC. The input reed relay shall be operated by ''clean" contacts on the HV distance protection.

The isolation requirements of the protection interface shall be for 2KV RMS.

i) Channel Allocations

The VF allocations required for tele-protection channels shall be provided.

j) Mechanical Details

The equipment shall be mounted cubicles of rigid construction and shall be dust and vermin proof. The cubicles door(s) shall be lockable.

14.8 ALARM FACILITIES FOR INTERNAL FAULTS

Each PLC cubicle requisite number of alarm lamps shall be provided for internal fault of PLC equipment such as Inductic failure, Protection fail etc.

14.9 48V BATTERY CHARGER/BATTERY SUPPLIES

a) General

Two sets of batteries with chargers shall be provided at the substation. The batteries, supplied as two half batteries shall be of the nickel cadmium alkaline type. Each charger shall normally have separate 'boost' and 'float' charge units.

The charger equipment shall comply with the requirements of IEC 146 (BS 4417) and shall be self protecting in the event of overlaods.

b) Battery Chargers

The 48V batteries shall normally be kept charged by a charger unit comprising of a float charger and a boost charger.

The battery shall be supplied in two 'half' batteries and the charging arrangements such that after an AC mains failure (or for maintenance purposes) if shall be possible to disconnect the one 'half' battery from the load so that it can be boost charged by the boost charger while the float charger supplies the load with other 'half' battery. When the first 'half' battery is fully charged it shall be possible to switch it to the float charger feeding the load while the other half battery is connected to the boost conditions no volt contactors shall automatically parallel the two half batteries.

Float Charging Conditions

The automatic charger shall maintain the battery normally floating so that no discharge occurs under normal loading and the battery remains fully charged.

Chargers shall be designed for single phase or three phase AC auxiliary supplies with nominal voltages of 240V/415V + 10% 47/53Hz and shall maintain the float charge automatically irrespective of variations in the voltage of the AC supply within the specified limits.

The automatic float charger output voltage shall not vary by more than plus or minus 1% of the nominal float charge value when connected to the load and operating under any combination of the following conditions:

i) Frequency variation 47 to 53Hz
ii) Rated output AC voltage variation plus or minus 6%
iii) Output between 0 and 100% of the rating

The output voltage regulator shall be adjustable within approved limits and shall be so designed that special tools are not required for such adjustment. The reference voltage point for control of the charger output voltage shall not be obtained from a source external to the charger. The output of the charger on float charge shall be equal to the normal battery standing load plus recommended finishing charge rate.

When the battery is connected to the charger, the posphometric noise level at the output for loads between 0% and 100% shall not exceed the equivalent of 2 millivolts at a frequency of 800Hz after weighting as specified by OCCITT.

Boost Charging Conditions

The boost charger shall recharge the battery after a heavy discharge. The voltage/current characteristics shall have a tapering characteristics in order to minimise gassing during the finishing period of a conditioning charge.

At normal rated input voltage and frequency the boost charger output shall be not less than its specified rating at any battery voltage within the range of nominal rating plus 20% or such other range as is approved. The maximum voltage for the boost charger when delivering the recommended finishing charge shall be not less than 1.7V per cell for nickel or cadmium alkaline batteries.

Indicating Instruments

The following shall be provided:

i) input voltmeter
ii) output voltmeter
iii) output ammeter
iv) charge/discharge ammeter

Controls and Alarms

Each charger shall be equipped with a switch fuse for the incoming AC supply and either an off-load isolator or disconnecting links for the DC output.

For the outstation batteries two sets of disconnecting links shall be fitted to the boost charger; one for each section of the battery. All switchgear and isolators shall comply with the requirements of BS 5419.

The following alarms shall be provided as minimum; mains failure, charger fail, high volts, low volts. Clean changeover contacts shall be provided for external alarms.

Distribution Board

DC distribution panels shall be provided in each charger cubicle for up to 10 outlets. Each main item of equipment shall have a direct power supply connection. Teed connections will not be permitted.

c) **48V Batteries**

The batteries shall be of the high performance nickel cadmium type and shall be designed for a life expectancy of at least 25 years under the conditioins of service likely to be encountered by the equipment detailed in this Specification.

A complete set of test and maintenance accessories suitably boxed shall be provided for each battery. A syringe hydrometer and a durable instruction card shall be included in each set.

Battery cases shall be of high impact polystyrenes translucent plastic.

Cells shall be numbered consequently and terminal cells marked to indicate polarity.

15.0 PERFORMANCE PENALTIES

The following penalties shall be applied in the event of failure to meet guarantees:

- R.O. 1000/- for each KVA less than the nominal rating at the specified guaranteed temeprature rises (applied to transformers –
  Tolerance 1%
- R.O. 800/- for each KW iron losses exceeding the guaranteed losses (applied to transformers)
- R.O. 200/- for each KW copper and other load dependent losses (applied to transformers)
- R.O. 1000/- for each db exceeding the guaranteed noise level (applied to transformers)
- R.O. 2000/- for 1% current carrying capacity falling short (applied to 132KV busbars, 33KV busbars, 132KV bus coupler, 33KV bus coupler, 132KV feeders and 33KV feeders. –
  Tolerance 1%
- R.O. 500/- per 132KV switchgear bay for 1% SF6 gas losses exceeding the rated annual losses.

16.0 INSPECTION AND TESTING PART A – MANUFACTURE

16.1 GENERAL REQUIREMENTS

The whole of the plant shall be subject to inspection and test by a designated inspection agency appointed by the purchaser during manufacture, erection and on completion.

The approval of the results of any such inspection or test shall not prejudice the right of the owner to reject the plant if it fails to comply with the specification when erected or to give complete satisfaction in service. The costs of all tests including the provision of the necessary test equipment whether at the manufacturer's works or on site shall be deemed to be included in the price of the plant.

Before any plant is packed or despatched from the works, all tests called for shall be successfully carried out. Certificates of all tests carried out shall be submitted. Adequate notice shall be given when the plant is ready for inspection or test and every facility shall be provided to enable the inspection agency to carry out the necessary inspections and tests.

16.2 INSPECTION AND TESTING DURING MANUFACTURE

Every facility shall be provided to enable the inspection agency to carry out the necessary inspection of the equipment. Costs of all tests during manufacture and preparation of test records shall be included in the price of the equipment.

Test instruments shall be approved and shall if calibrated by the National Physical Laboratory or such other body as may be approved.

Breakdown test voltages shall be measured by means of a crest or electro-static voltmeters connected to the high voltage side of the transformer or by an instrument connected to the low voltage side of the transformer supplying the test voltage, and calibrated in an approved manner by means of a sphere gap. Electrical tests other than impulse tests shall be carried out at a frequency of 50Hz.

16.3 TESTS AT MANUFACTURER'S WORKS

Works tests shall include all routine electrical, mechanical and hydraulic tests in accordance with the relevant standards and this specification and in addition any tests called for by the inspection agency to ensure that the plant being supplied meets the requirements of the specification.

One complete equipment of each type and rating shall be subjected to type tests as specified in the relevant IEC or BS. In the event of certified copies of type test certificates covering equipment of similar design rating and construction type tests may be waived. The price of equipment shall include for the carrying out of such type tests where certificates are not already held.

Should the plant or any portion thereof fail under test to give the required performance, further tests which are considered necessary shall be carried out.

After satisfactory completion of the witnessed tests at the works, the plant shall be submitted for approval during dismantling prior to shipping.

No plant shall be despatched to site until release note is issued by inspection agency.

16.4 TEST CERTIFICATES

Triplicate sets of all principal test records, test certificates and performance curves shall be provided for all tests carried out. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers.

16.5 REJECTION OF PLANT

Any item of plant or component which fails to comply with the requirements of this specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site may be rejected either in whole or in part as considered necessary.

After adjustment or modification the item of equipment shall be submitted for further inspection and/or tests. Plant or components with defects of such a nautre that the requirements of this specification cannot be fulfilled by adjustment or modification shall be replaced at no extra cost.

16.6 PART – B: TESTS AT SITE

Before any part of the plant or equipment is commissioned for commercial use, it shall be subjected to mechanical, electrical, operational and other tests as required to prove its compliance with the specification. All official tests shall be witnessed by the owner's site engineer. The results of all tests carried out, including any tests carried out independently shall be recorded in writing and four copies handed over within 7 days of the test.

All necessary apparatus, instruments, equipment and labour to carry out the tests shall be provided the costs of which shall be included in the contract price.

All materials, plant and equipment which fail to pass the tests due to or arising from faulty design, material or workmanship, or due to incorrect erection shall be replaced, repaired or adjusted and further tests carried out.

Taking over certificate will be issued only when the individual system has been completed, energised and after all tests and adjustments have been carried out.

16.7 CIVIL WORKS

Soil tests, using approved methods and instruments shall be carried out to determine the load bearing quanlities of the soil to ensure that the foundation design is suitable for the building and equipment to be placed thereon. During the course of the building construction works, tests on concrete mixes and other materials shall be carried out in accordance with the specification.

16.8 LIGHTING AND SMALL POWER INSTALLATION

The complete installation or any part thereof shall be tested, both before and after connection as stipulated in OES 4.

16.9 SCHEDULE OF TESTS
GENERAL

The following list gives the minimum requirements:

16.10 TRANSFORMERS

The following tests are to be conducted on transformers:

Work Tests

1) Summary of Tests

a) Transformers – Routine and Type Tests to IEC 76 Parts 1,2,4, and 5 and BS 171 : 1970 in respect of dielectric tests.
b) Voltage Control Equipment – Routine and Type Tests to IEC 214 : 1976.
c) Magnetic Circuit – Routine Tests.
d) Cables Boxes and Disconnecting Chambers – Routine Tests.
e) Porcelain Insulators – Routine, Sample & Type Tests to IEC 137 : 1973, IEC 233 : 1967 or BS 3297.
f) Complete Outdoor Bushing Assemblies – Routine Tests including partial discharge measurements for 132KV and higher voltage sample and type tests to IEC 37 : 1973.
g) Tanks – Routine Tests and Type Tests.
h) Cooling Plant – Routine Tests.
i) Gas and Oil – Actuated Relays – Routine Tests.
j) Galvanising – Routine Tests.

A) ROUTINE AND TYPE TESTS

a) Routine Tests

All transformers shall be subject to the following routine tests:

1) Measurement of winding resistance on all tap positions and phases

2) Ratio, polarity and phase relationship
3) Impedance voltage
4) Load losses
5) No load loss and no load current
6) Induced over voltage withstand including partial discharge measurements to IEC 270 : 1968
7) Separate source voltage withstand
8) Insulation resistance
9) Noise level tests to NEMA Standards Publication TRI : 1962.

b) Type Tests

Temperature Rise Test: The test shall be in accordance with IEC 76 Part 2, and shall be carried out on one transformer of each size and type. Temperature rise tests shall be conducted on the tapping corresponding to the maximum losses.

c) Special Tests

Impulse Voltage Withstand Tests : They shall be made on one on each transforer and shall include the following requirements:

1) The transformers shall have been subjected to the above routine tests prior to the impulse voltage withstand tests.
2) Impulse test regulating windings shall be carried out on the tap position at which, according to recurrent surge generator tests, the maximum stress occurs.
3) When impulse tests are carried out on LV windings by the transferred surge method, oscilloscope reocrd shall be made of the current flowing to earth from the LV winding.
4) The procedure shall be as required by BS 171: 1970 Clause 35.3, the impulse test voltages being applied successively to each line terminal. Negative polarity is to be used through out the tests.
5) The sequence of voltage applications shall be:

    a) Impulse calibration test at 75% of the specified full wave voltage.
    b) One 100% full wave voltage application
    c) Two 115% minimum chopped wave voltage application
    d) One 100% wave application.
    e) Repeat of calibration test of 75% of the specified full wave voltage.

    Oscillographic records of the applied voltage and neutral current and/or transferred voltage are to be taken and included in the records.

    Films of the oscillographic records are to be made available to the engineer at the time of the tests for his examination.

    External flashover of the bushings during the chopped we tests if not permitted.

6) At the conclusion of the impulse voltage withstand tests, the transformers shall again be subjected to the routine tests (a), (a-5) and (a-8) above.
7) Zero phase sequence impedance measurement. This test shall be carried out in accordance with IEC 76 or BS 171. .

B) VOLTAGE CONTROL EQUIPMENT

Routine Tests

Each finished tap changer is to be subjected to the routine test specified in IEC 214 : 1976 but in addition the mechanical test shall be carried out at rated voltage and no load.

Type Tests

Shall be carried out entirely in accordance with BS 4571.

C) MAGNETIC CIRCUIT

Routine Tests

Each core completely assembled is to be tested for one minute at 2000 volts AC between core bolts, side plates, structural steel work and core at the core and coils stage. After the transformer is tanked and completely assembled, a further test is to be applied between the core and the earthed structural steel work to prove that the core is earthed through the removable link, at one point only.

D) CABLE BOXES AND DISCONNECTING CHAMBERS

Routine Tests

To meet the requirements of subsection.

E) PORCELAIN INSULATORS

The following tests are to be made on not less than 2% with a minimum of two of the porcelain insulators of each type.

a). Temperature cycle test
b) Porosity test

F) COMPLETE OUTDOOR BUSHING ASSEMBLIES WITH PORCELAIN INSULATORS

Routine Tests to include:

a) Oil leakage test
b) 50Hz dry withstand test
c) Power factor/voltage test

Type Tests to include:

a) 50Hz wet withstand test
b) Visible discharge test
c) Impulse voltage test
d) Flashover under oil test

G) TANKS

Routine Tests

Oil leakage – all tanks, conservators and oil filled compartments which are subjected in service or during maintenance to oil pressure are to withstand without leakage, a hydraulic pressure test equal to 69 Kn/Sq m

or the normal pressure plus 34 Kn/Sq m whichever is the greater, for 24 hours during which time no leakage or oil ingress into normally oil free space shall occur.

Type Tests

Unless type test certificates can be produced for tests carried out on similar equipment, the following tests are to be included for tanks, conservators and pressure relief devices.

a) Vacuum Test – the equipment is to withstand of 50cm of mercury when empty of oil. The permanent deflection of plates or stiffeners on removal of vacuum is not to exceed the following values:

Length of Plates	**Permanent deflection**
Less than 1300mm	3.17 mm
1300 to 2500mm	9.5 mm
Greater than 2500mm	12.7 mm

b) Pressure Test – the equipment is to withstand a pressure corresponding to 69 Kn/ Sq. m or the normal pressure plus 34 Kn/ Sq. m whichever is greater. The permanent deflection of plates or stiffeners on removal of pressure is not to exceed the value stated in respect of the vacuum test in the preceding paragraph.

H) COOLING PLANT

Routine Tests

a) Coolers – pressure test to be as specified in section (G) – (b) above.
b) Oil Pumps, oil pipework and valves – a hydraulic withstand pressure of 138 KN/m^2 for 15 minutes.
c) Water pumps, water pipework and valves – a hydraulic withstand pressure of 345 KN/m^2 for 15 minutes.
d) Motor and control gear – to the requirements of Clauses 0.51 and 0.52.

I) GAS AND OIL – ACTUATED RELAYS

Routine Tests

a) Oil Leakage – when subject to an internal oil pressure of 207 KN/m^2 for 15 minutes.
b) Gas collection
c) Oil surge
d) Performance test under service conditions including starting and stopping of oil pumps
e) Voltage – 2KV for one minute between electrical circuits casing

J) GALVANISING

Routine Tests

To the requirements of OES 11.

K) SITE TESTS

All apparatus, instruments and connections for the tests after the completion of the erection work on Site shall be provided. The following tests shall be performed:

a) Insulation resistance tests
b) Insulation resistance test at 500V between core and core clamping structure
c) Voltage withstand tests on transformer oil to BS 148
d) Ratio
e) Phase relationship
f) Magnetisation characteristics of current transformers of winding temperature devices
g) Calibration of winding temperature devices
h) Tap selector and diverter switch alignment
i) Calibration of automatic voltage control equipment
j) Magnetisation characteristics and polarity tests on current transformers where provided and installed in terminal bushings under this contract.

16.11 CABLES

Cables shall be tested as follows:

A) GENERAL

The cables shall be inspected and tested in accordance with Section 13 of this Specification.

B) HIGH VOLTAGE/PARTIAL DISCHARGE TEST

Each completed cable drum shall be subjected to a combined high voltage/partial discharge test to measure the permissible discharge. The AC test voltages shall be applied between the conductor and the core screen which shall be connected to earth. The tests shall be made at room temperature.

Rated Voltage E	132KV			33KV		
Step No	1	2	3	1	2	3
Test Voltage (KV)	100	185	100	26	49	26
Permission Discharge (pc)	5	30*	5	10	30*	10

*** For cables having extruded outer semi conducting screen.**

No breakdown of the insulation shall occur. The permissible break down discharge noise levels shall be less than 2.5 pc for 132KV cables and 5.0 pc for 33KV cables.

C) CONDUCTOR RESISTANCE TEST

The DC reistance of the conductor of the completed cable shall be measured and when corrected to 20 Deg. C shall not exceed the guaranteed values stated in the Schedule of Particulars and Guarantees.

D) CAPACITANCE TEST

The capacitance of each core of every drum length of completed cable shall be measured at room temperature and recorded on the test certificate.

E) INSULATION THICKNESS MEASUREMENT

The measurement of the insulation thickness shall be determined from a representative sample of the cable not more than 150mm in length taken not less than 300mm from the end of each factory length. Measurements shall be made by an optical method in which the error of determination does not exceed 0.025mm. The measurements shall be made at six approximately equally spaced points round the periphery of the sample and care shall be taken to ensure that the minimum thickness is measured.

The minimum average of the measurements shall be not less than the value stated in the Schedule of Particulars and Guarantees.

F) VOLTAGE TEST ON OUTER COVERING

Each drum length of completed cable shall withstand a voltage test for one minute between the metal screen and the external conducting surface of the extruded PVC oversheath. The DC test voltage shall be equal to 8 KV/mm thickness of covering with a maximum of 25 KV or, alternatively, the AC test voltage shall be 4 KV/rms per mm thickness with a maximum of 12.5KV. The minimum average thickness of oversheath specified shall be used for calculating the test voltage.
If the cable outersheath is not provided with a packed on graphite coating, the cable drum length shall be completely immersed in water for the execution of this test.

G) MEASUREMENT OF EXTRUDED BEDDING & OVERSHEATH THICKNESS

The thickness of the bedding and oversheath shall be measured on a representative sample taken from the cable, not less than 150mm from the end of a manufacturing length, by a method in which the error or determination does not exceed 0.025mm(e.g. by use of a micro meter or an optical device).

H) CAPACITANCE TEST

The electrostatic capacitance of each cable core shall be accurately measured and the results, converted to microfarads per 1000 meters shall be recorded on the Test Certificate.

I) INSULATION RESISTANCE TEST

The insulation resistance of EPR insulated cable only, heated to the rated maximum temperature for the installation shall be made between each conductor and its core screen and earth at room temperature.

The DC test voltage shall be any constant value between 3000 volts and 500 volts and shall be applied for a sufficient time, of not less than a minute to reach a steady measurement.

J) PARTIAL DISCHARGE TEST

All components of the test equipment shall have a sufficiently low noise level in order to achieve the required sensitivity.

The alternating test voltage, at any frequency between 49 Hz and 61Hz shall be raised sufficiently to result in clear indications of detection circuit response to partial discharge within the cable sample under test, except that, if the existence of discharges is not evident after the voltage has been raised to a value of 20% in excess of the required partial discharge extinction voltage, e.g. 120% of 1.25 times working voltage to the cable shall be considered to have satisfied this test.

The partial discharge extinction voltage level shall not be lower than 1.25 Eo for approval when measured as stated in IEC Standard 540. The actual value for each core shall be recorded on the sample test certificate.

K) BENDING TEST

After the electrical tests specified above the cable shall undergo at ambient temperature, which shall normally be higher than 4 Deg. C a bending test round a test cylinder. The diamter of the cylinder shall be not greater than 18D for single core cable and 16D for three core cables where D = Outer diamter of cable.

Each bending cycle shall consist of winding the cable onto the test drum unwinding, rewinding onto the test drum in the reverse direction and unwinding. The cable shall be bent along the same axis in each case and the full cycle shall be completed three times.

L) VOLTAGE TEST

After completion of the bending test the cable shall be subjected to an AC voltage test of 3.5 Eo at a frequency of 49-61Hz between the conductor and the core screen which shall be connected to earth for a period of one hour.

The voltage shall then be decreased gradually to 2.5 Eo and kept at that value for one minute. The permissible discharge shall be measured and shall not be greater than 30 pc.

The discharge extinction voltage shall then be measured using an applied AC voltage at any frequency betwee 49 and 61Hz and the results shall be stated on the sample test certificate.

M) ROUTINE TESTS ON SITE

1) Conductor Resistance Test

When the installation of cables and associated jointing accessories has been completed, the DC resistance of each conductor shall be measured and recorded and when corrected to 20 Deg. C, shall not exceed the guaranteed value given in the Schedule of Particulars and Guarantees.

2) High Voltage Test

After the conductor resistance test, each cable shall be subjected to a DC voltage of 2E (where E is the rated voltage) applied for a period of 15 minutes between the conductor and the core screens which shall be connected to earth. The test voltage shall be raised gradually to the specified value at which point the test period shall begin. There shall be no breakdown of the electrical insulation.

3) Voltage Test on Outer Covering

The outersheath of each cable length shall be tested after laying but prior to jointing and backfilling above concrete slabs. The DC voltage shall be equal to 4KV for each mm of thickness of oversheath with a maximum of 10KV.

After completion of the installtion, all insulating provisions, including external joint insulation, terminal base insulation, bonding leads etc. shall withstand a high voltage DC test equal to 2KV

for each mm thickness of oversheath with a maximum of 5KV DC. The test voltages shall be calculated on the minimum average thickness stated in the Schedule of Particulars and Guarantees. The duration of the tests shall be one minute and the leakage current recorded for each cable.

This test shall be repeated every six months during the maintenance period.

16.12 POWER LINE CARRIER AND ASSOCIATED EQUIPMENT

The power line carrier, Tele-Protection, automatic telephone exchange and other equipment shall be tested as follows:

A) GENERAL

The inspection and testing of the equipment specified shall comply with the general requirements specified.

B) BARRIER ISOLATION TESTS

1) General

The following "barrier isolation" tests shall be carried out on power supplies and connections to/ from HV plant:

- Damage Tests: no permanent damage to the equipment shall be observed. For convenience, except for tests on power supplies, the equipment need not normally be energised for these tests.

- Mal Operation Tests : with the equipment energised, no mal operation shall occur as a result of these test, i.e. no false trips or control operations.

1) Power Supplies

- Damage Tests: 24/48 V DC withstand application of any voltage upto 30/60V.

- 220V AC and/or 110V DC and/or 48V DC and/or 24V DC

Withstand application of upto 10 times.

AMPLITUDE	DURATION
% of Supply RMS or DC Voltage	Milli – Seconds
300	10
200	1
300	0.02
500	0.005

Withstand upto 10 times each, interruption of supplies for periods of 5 mS, 100 mS and 500 mS (BS 4509, Clause 2.4.13.2) and upto 20 seconds.

3) **Connection To/From HV Plant**

- Damage Tests : withstand application of BEAMA 219 : 1966 test i.e. 5KV, 0.5 Joule for 1/50 microseconds, between terminals of the same circuit and between circuits not normally connected together.

- Normally open contacts of relays feeding outwards from the tele-control equipment shall withstand a voltage of 1KV RMS 50 Hz AC for 1 minute between all terminals connected together and earth and between circuits not normally connected together (BS 142:1966 Section 14 Clause 46.1.4).

- The insulation resistance shall not be less than 20 megohms when measured at 500V AC RMS, 50 Hz or 750 V DC applied for a period not exceeding one minute between all terminals connected together and earth and between circuits not normally connected together.

4) **Mal Operation Tests**

1000 V RMS 50Hz AC (source impedance – 150 Ohms) shall be applied for a minimum of 1 second between earth and the signal terminal via a 0.2 uF capacitor for DC isolation.

C) **TESTS AT MANUFACTURERS WORKS**

1) **Operating Tests – Carrier Equipment (Routine)**

Back to back system tests shall be carried out including overall frequency response, speech and signalling tests.

In addition, the contractor shall carry out factory tests to determine the characteristics including, but not limited to:

- Transmitter frequency stability
- Receiver sensitivity
- Receiver signal to noise ratio
- Receiver selectivity
- Receiver base band regulation
- Transmission frequency response
- Transmitter harmonic distoration
- Overall loop gain
- Line trap tuning
- Capacitance of the coupling capacitors
- Coupling unit characteristics

and any other reasonable tests which engineer so requires providing notice is given of such tests.

Operating Tests – Telephone Equipment (Routine)

Back to back tests shall be carried out to check correct functioning of the exchange at normal and low supply volts. Priority tests etc. shall also be conducted as shall transit working.

Operating Tests – Teleprotection Equipment (Routine)

Back to back tests shall be carried out via the PLC links to determine the satisfactory operation of the Tele-Protection as in Section 11 of the Specification.

Operating Tests – System

Full system tests shall be carried out to prove the compatibility of all the various types of equipment being supplied with each other and that all system requirements have been achieved as specified. The contractor must also prove that the equipment being supplied is totally compatible with any existing equipment.

2) **Routine Tests**

The routine tests shall include, but shall not be limited to, the following:

Relay Adjustments

All relays which are specified to have individual adjustments shall be checked in accordance with the data sheets.

Insulation Tests for Relays

Windings and all spring combinations of each relay shall be tested at 500V or 2KV (as may be specified) to the yoke. Where the relay is intended to be insulated form its mounting, a similar test shall be make between yoke or relay frame and the mounting and cover.

Wiring

All apparatus on each pane, cubicle or rack shall be tested to a voltage equal to the test voltage specified for the apparatus connected to it.

Line Isolation Equipment – 2KV or 5KV

Line isolation equipment specified to withstand 2000V AC or 5000V shall be tested at these voltages between the line terminals and the apparatus terminals and the frame work and covers.

3) Test Schedule

The contractor shall submit a proposed test schedule for the system tests and shall state in the schedule the total allowable outage time for the system.

The test schedule shall include:

- Test of the whole system to check its performance operationally
- Facility check of power line carrier system
- Facility check of automatic telephone system
- Check foregoing against specified variation in power supplies

D) ACCEPTANCE CONDITIONS

The test shall only be deemed to be successful if the following conditions apply:

i) No breakdown of any part of the system in excess of that detailed in the test schedule and the total allowable outage time is not exceeded.

ii) No series of errors/faults on a particular item indicating a design weakness.

Should any plant or any portion thereof fail under test to give the required performance, further tests which are considered necessary by the site engineer shall be carried out and cost of the completed tests shall be included in the price of works.

After satisfactory completion of the witnessed tests at the works, plant shall be submitted for approval for dismantling prior to shipping. No item of plant shall be despatched to site until the inspection agency has given its approval in writing.

E) SYSTEM TESTS ON SITE

All plant shall be submitted for site tests and inspection as required by the site engineer. During the course of erection, the site engineer shall have full access for inspection of the progress of the work and for checking workmanship and accuracy as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the site engineer to demonstrate that it is entirely suitable for commercial operation. In connection with this, the owner will provide only electricity, fuel and water for the purpose of carrying out the tests and such labour and materials and apparatus that may be required shall be supplied.

Commissioning tests shall be carried out in the presence of and to the satisfaction of the site engineer.

All apparatus shall be tested on site conditions in which it will normally work with additional arrangements as required to prove the capacity for working under the worst combination of conditions.

The commissioning tests shall be exhaustive and shall demonstrate that the overall performance of the works satisfied every requirement specified.

The tests to be carried out shall be:

i) Based on such routine tests as can conveniently be applied on site together with any other test required.

ii) A system test embracing all the equipment to satisfy the requirements.

F) TEST CERTIFICATES

Triplicate sets of all principal test records, test certificates and performance curves shall be supplied for all tests carried out in accordance with the provision of this specification. These test certificate records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the site engineer. Informaton given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers.

G) REJECTION OF PLANT

Any item of plant or component which fails to comply with the requiremnts of this specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site may be rejected either in whole or part as deemed the contrary.

After adjustment or modifcation if so directed by the engineer the contractor shall submit the item for further inspection and/or tests. Plant or components with defects of such nature that the requiremnets of the specification cannot be met by adjustments or modifcation shall be replaced by the contractor at his own expense and to the satisfaction of the engineer.

16.13 SWITCHGEAR AND OTHER SUBSTATION EQUIPMENT

The following list gives the minimum requirements for switchgear and other substation equipment:

WORK TESTS

1) Complete Switchgear Requirements

Routine high voltage
Electrical type tests

2) Circuit Breakers

Routine Tests

One circuit breaker of each type ordered shall be fully assembled at the manufacturer's works and subjected to routine tests in accordance with BS 5311 or IEC 56 and shall comprise:

a) Operation tests
b) Millivolt drop test
c) Power frequency voltage test

The remaining circuit breakers of each type shall be either fully assembled at the manufacturer's works and subjected to tests (a) and (c) above or where not assembled at works, separate power frequency voltage tests shall be performed on all major insulation components.

Type Tests

Making and breaking capacity tests for circuit breakers are to be in accordance with BS 5311 or IEC 56.

3) Bushings

Routine, sample and type tests to BS 223 or IEC equivalent.

4) Current and Voltage Transformers

Routine tests to IEC 185, 186, 186A and 358 requirements or BS 3938 and 3941.

Type tests IEC 185, 186, 186A requirements or BS 3938 and 3941 and including impulse tests.

Refer to Clause 3.7

5) Capacitor Couplers and Line Traps

Routine Tests : Ratio and phase angle errors of capacitor divider.

6) Surge Arrestors

Routine tests to IEC 99 requirements or BS 2914.
Type tests to IEC 99 requirements or BS 2914.

7) Neutral Earthing Resistors

Routine leakage and over voltage tests.

8) **Capacitors**

Routine tests to IEC 70 requirements or BS 1650.
Type tests to IEC 70 requirements or BS 1650.

9) **Auxiliary Transformers, Motors, Rectifiers, Contactors and Control Gear**

As appropriate IEC requirements or BS and as required by this Specification.

10) **Protective Relaying Equipment**

Routine tests to BS 142 and checking of correct operation of all relays as appropriate.

Routine testing of sets of differential current transformers.

Type tests of each type of protective scheme simulating service conditions as closely as possible, to prove sensitivity, stability and operating times.

11) **Control and Indicating Panels, Instruments, Wiring, Metering Equipment Etc.**

Routine tests to the appropriate IEC or BS requirements and high voltage tests.

12) **Batteries and Chargers**

Material tests as required. Sample tests on cells for repeated discharge/charge/discharge (alkaline only).

16.14 SITE TESTS

1) Soil resistivity tests and electrode and earthing system tests as specified.

2) Routine high voltage tests.

In the case of 132KV equipment other than cables the Contractor will not be required to provide a high voltage test set. A working voltage test will be made by arrangement with the Employer.

For cables site testing is required in accordance with the appropriate IEC requirement or BS and the Contractor is to provide the necessary test facilities.

3) Insulation resistance tests.

4) Continuity tests.

5) Oil tests.

6) Tests to prove correct operation of interlocks, tripping and closing circuits, indications etc.

7) Vector group, phasing and synchronising tests.

8) Operation of all protective gear circuits by primary and secondary injection and where necessary system fault tests to check sensitivity and stability.

9) Protective gear limiting tests as may be necessary.

10) Test operation of alarm devices.

11) Rotational tests on all motors.

12) Battery capacity test.

16.15 COMMISSIONING TESTS

Details for the following shall be submitted to the employer for review and approval prior to the start of commissioning activities.

a) **Commissioning procedures**

The draft procedural details shall highlight the method of conducting the site tests as per the requirement under item 16.14. The details shall mainly cover the circuit diagram of test set up wherever applicable and a tabular form to record the test results. Each test record shall have provision to record the serial number and name plate details of the relevant equipment under test. The formats will be reviewed and approved by the Employer.

b) A check list shall be prepared listing out the check on Interlocks closing/opening operation, protection tripping etc. for each equipment or system.

c) Detailed calculations for arriving at the protective relay settings for incomers and feeder circuits, transformers, protection shall be prepared. The relay settings shall be shown in a tabular form showing the circuit description, type of relay, available setting range and recommended setting.

d) Protective relay coordination curves plotted on log log scale shall be furnished to the Employer along with the relay recommended settings.

STANDARD OES-27
132/33KV SUBSTATION

VOLUME-2
2 X 63MVA 132/33KV TRANSFORMER & 132KV OUTDOOR SF6 SWITCHGEAR

SCHEDULE – A
SCHEDULE OF REQUIREMENTS

1.0 132 KV OUTDOOR SWITCHGEAR

1.1 Seven (7) bays 132KV outdoor switchgear, comprising SF6 insulated outdoor circuit breakers, isolators, voltage transformers, current transformers, associated mounting structures, duplicate busbars designated as Busbar I and Busbar II and the 8 bays classified as follows:

BAY NO.	DESIGNATION	BAY TYPE	DUTY
1	Outgoing Feeder	A	132KV Feeder
2	Incoming Feeder	A	132KV Feeder
3	63MVA Tx. No. 1	B	63MVA Tx.
4	Bus Section	C	Bus Section
5	63MVA Tx. No. 2	B	63MVA Tx.
6	Feeder	A	132KV Feeder
7	Feeder	A	132KV Feeder
8	Bus Coupler	D	Bus Coupler

The equipment requirements are as follows:-

Item No.	Description
A 4	**Feeder Circuit**

a) One 3 pole, 132KV, 2000A, 31.5KA circuit breaker, complete with steel supporting structure, ganged operating devices, closing and tripping mechanism, duplicated tripping coils, operating gear, locks, interlocks, local/remote selector, auxiliary switches, operating counter and internal wiring. The circuit breaker shall be suitable for delayed auto reclose duties.

b) One set of three post type current transformers with cores as detailed below, complete with supporting structures and terminal boxes for multicore cables. Each core shall have a class and burden to suit the particular application.

i) Ratio 400/1A Class X for distance protection and fault location equipment.

ii) Ratio 400/1A Class 5P10 for directional over current, directional earth fault and sensitive earth fault protection.

iii) Ratio 400/1A Class 5P10 for instruments.

iv) Ratio 2000/1A Class X for busbar zone protection.

V) Ratio 2000/1A Class X for busbar zone check protection.

c) One three pole 132KV 2000A 31.5KA line isolator with three pole line earthing switch, complete with supporting structure, operating mechanism, locks, mechanical and electrical interlocks, auxiliary switches and labels.

d) Two 3 pole 132KV 2000A busbar isolator, complete with supporting structure, operating mechanism, locks, electrical interlocks, auxiliary switches and labels.

e) One set of 3 capacitor type single phase voltage transformers, ratio 132000/1.732: 110/1.732 110/3 volts class B. Red and Blue phases to be suitable for mounting HF line traps and HF coupling equipment (provided by others). To be complete with brackets for mounting boxes for multicore cables, low voltage fuses and supporting structure.

f) One three phase set of 132KV surge arrestors with supporting structures and surge counters.

g) One steel structure, complete with facility for termination of final span from overhead line terminal tower. To be complete with access ladder.

h) One three pahse set of rigid and flexible connectors, clamps, (bi-metal where necessary), conductors, insulators, support structures, fittings, turnbuckles etc. to complete the connections from the overhead line slack span to the busbar. Primary conductor current rating 800A.

i) One outdoor multicore cable marshalling kiosk, complete with lock, internal light and heater, for marshalling all multicore cables from outdoor switchgear (circuit breakers, isolators, current and voltage transformers etc.).

B 2 63MVA 132/33KV Transformer Feeder

a) One 3 pole 132KV circuit breaker as per type ''A".

b) Two Nos. 3 Pole isolators as per Type ''A"

c) Other items as per Type ''A".

C Bus Section

a) One 3 Pole, 132KV 2500 Amp 31.5KV circuit breaker with accessories as per Type ''A".All other itmes as per Type ''A".

b) One set of post type current transformers with cores detailed below:

(i) Ratio 2000/1A Class 5^P 10 for over current protection.

(ii) Ratio 2000/1 A Class x bus bar zone protection.

(iii) Ratio 2000/1 A Class x bus bar zone check protects.

c) Two three pole 132KV 2500A 40KA bus bar isolator complete with supporting structures.

d) Necessary connectors, clamps, support insulators, structures, fittings etc. to complete the bus section connection to the system.

D Bus Coupler

a) One 3-pole. 132KV circuit breaker 2500A 40KA

b) One set of post type current transformers with cores detailed belc v

(i) Ratio 2000/1 Class x bus zone protection

(ii) Ratio 2000/1 class x bus zone check protection

c) Two three pole 132KV 2500A 40KA busbar Isolator complete with supporting structure.

d) Necessary connectors, clamps, support Insulation, structures, fitting to complete the bus coupler connection to the system.

E 132 KV bus bar and miscellaneous items.

a) one set of bus bars comprising

(i) bus bars rated at 2000A, 31.5KA 3 phase.

(ii) Bus bar supporting insulator with steel structures

(iii) All rigid, flexible and expansion joints and coupling connection

b) One set of steel structures for once head substation connection. To be complete with access ladders, screens facilities for terminating slack spars from over head lines.

c) One set of over head earthwise seems comprising 4 steel supporting masks with clamps, jumpers etc. for supporting one head copper earthwise and over head line earthwine.

d) One set of copper earthwires to form over head earthing screen.

e) Two sets of portable earthing equipment.

1.2 PROTECTION, METERING AND CONTROL

Control Board for 132KV Switchgear

Circuit Type	Quantity	Description
A	4	Control equipment for 132KV feeders comprising:

Section of mimic diagram including discrepancy type. Control switches for circuit breaker, isolators, high speed earthing switch and discrepancy type position indication for hand operated earthing switches

1 – "Trip circuit healthy" white indication lamp
1 – "Fault trip" amber indication lamp
1 – Remote/Supervisory selector switch
1 – Ammeter selector switch
1 – Ammeter scaled 0-400A and 0-800A on reverse side
1 – Voltmeter scaled 0-150KV with selector switch
1 – MW meter bi-directional 150-0.150/75-0-75MW
1 – Push button for "dead busbars" closing
1 – Socket for synchronizing equipment
1 – Synchronising selector switch

Wiring, cable glands, fuses, links, terminal blocks, terminals, labels etc. complete.

B 2 Control equipment for 63MVA transformers comprising:

Section of mimic diagram including discrepancy type control switches for circuit breaker isolators and high speed earthing switch and discrepancy type position indicator for hand operated earthing switch

1 – "Trip circuit healthy" white lamp
1 – "Fault trip" amber indication lamp
1 – "Remote/Supervisory selector switch
1 – Ammeter selector switch
1 – Ammeter scaled 0-400A

Wiring, cable glands, fuses, links, terminal blocks, terminals, labels etc. to complete.

D 1 Control equipment for Bus coupler comprising:

Section of mimic diagram including discrepancy type control switches for circuit breaker, load breaker sectionalisers, isolators and high speed earthing switches.

1 – "Trip circuit healthy" white indication lamp
1 – "Fault trip" amber indication lamp
1 – Remote/Supervisory selector switch
1 – Ammeter scaled 0-2000A
2 – Busbar voltmeters scaled 0-150KV with selector switch
– Wiring, cables glands, fuses, links, terminal blocks, terminals, labels etc. to complete
1 – Push button for "dead busbars" closing
1 – Socket for synchronising equipment
1 – Synchronising selector switch
1 – Hinged panel mounted on the bus coupler control panel complete with synchroscope, synchronizing lamps, voltmeters, switches, wiring, labels etc.

C 1 Control equipment for Bus Section comprising:

Section of mimic diagram including discrepancy type control switches for circuit breaker, load break sectionalisers, isolators and high speed earthing switches.

1 – "Trip circuit healthy" white indication lamp
1 – "Fault trip" amber indication lamp
1 – Remote/Supervisory selector switch
2 – Busbar voltmeters scaled 0-150 KV with selector switch

– Wiring, cables, glands, fuses, links, terminal blocks, terminals, labels etc. to complete.
1 – Push button for "dead busbars" closing
1 – Socket for synchronising equipment
1 – Synchronising selector switch

1.3 Relay Panels for 132KV Switchgear

Circuit Type	Quantity	Description
A	4	Relay panel for 132KV feeder equipped with:-

1 – Overcurrent and earth fault relay with three IDMT overcurrent elements and one IDMT earth fault element.
Relay setting ranges:

– Overcurrent IDMT 50 – 200%
– Earth Fault IDMT 10 – 40%

1 – Distance protection relay
1 – Tripping relay
1 – Trip circuit supervision relay.
Wiring, fuses, links, terminal blocks, cable glands, CT test blocks with shorting/isolating links, labels etc.
1 – Lockout relay

B	2	Relay panel for 63MVA transformer feeder equipped with:-

1 – Overcurrent and earth fault relay with three IDMT over-current elements and one IDMT earth fault relay
Relay setting ranges:

– Overcurrent IDMT 50 – 200%
– Earth faults IDMT 10 – 40%

1 – Restricted earth fault high impedence relay (132KV)
1 – Tripping relay
1 – Neutral earth fault realy (132KV) Definite time two stage current relay

1 – Trip circuit supervision relay
Wiring, fuses, links, terminal blocks, terminals, CT test blocks with shorting/isolating links, labels etc. to complete
1 – Lockout relay

D 1 Relay panel for bus coupler equipment with:

1 – Overcurrent and earth fault relay with three IDMT overcurrent elements and one earth fault element

Relay setting ranges:-

- Overcurrent IDMT 50 – 200%
- Earth Fault IDMT 10 – 40%

1 – Busbar and breaker back-up protection including facilities for modification and extension as well as for monitoring and testing
and auxiliary equipment
1 – Trip circuit supervision relay Wiring, fuses, links, terminal blocks, cable glands, C.T. test blocks with shorting/isolating links, labels etc.
1 – Lockout relay.

C 1 Relay panel for Bus Section equipment with:

1 – Overcurrent and earth fault relay with three IDMT overcurrent elements and one earth fault element.

Relay setting ranges:

- Overcurrent IDMT 50 – 200%
  Earth fault IDMT 10 – 40%

1 – Busbar and breaker back-up protection including facilities for modification and extension as well as for monitoring and testing and
auxiliary equipment
1 – Trip circuit supervision relay

- Wiring, fuses, links, terminal blocks, cable glands, C.T. test blocks with shorting/isolating links, labels etc.

1 – Lockout relay.

2.0 33KV INDOOR SWITCHGEAR

2.1 Thirteen (13) panel 33KV Indoor Single Busbar Switchgear classified as below:

Panel No.	Designation	Panel Type	Duty
1	Feeder	B	O/H line/UG cable feeder
2	Feeder	B	O/H line/UG cable feeder
3	Feeder	B	O/H line/UG cable feeder
4	Feeder	B	O/H line/UG cable feeder
5	20MVA Tx. 1 33/11KV	C	20 MVA 33/11KV Transformer
6	63MVA Tx. 1 132/33KV	A	132/33KV 63MVA Tx.
7	Bus Section	D	
8	63MVA Tx. 2 132/33KV	A	132/33KV 63MVA Tx.
9	20MVA Tx. 2 33/11KV	C	20 MVA 33/11KV Tx. 2
10	Feeder	B	O/H line/UG cable feeder
11	Feeder	B	O/H line/UG cable feeder
12	Feeder	B	O/H line/UG cable feeder
13	Feeder	B	O/H line/UG cable feeder
	Busbar V.T.	D	

The requirements are as follows:

Panel Type	Quantity		Description
A	2	a)	1600A busbar chamber and feeder termination and current transformer chamber and 1600A circuit breaker on truck with auxiliary switches shunt trip mechanism, closing mechanism. Busbars shall be rated 1600A under site conditions. Local control switch with pistol grip handle. – Local/Remote selector switch – Circuit breaker ''closed" indication – Circuit breaker ''Open" indication – Cable box for associated copper conductor XLPE cables – Auxiliary switches to include those for future supervisory indication – Terminals, terminal blocks, wiring, fuses, links, labels etc. to complete.
		b)	Current transformers of required class and accuracy to meet IEC and B.S.:
		i)	1 metering commercial grade CT's ratio 1600/1 Class 0.5
		ii)	3 restricted earth fault and transformer differential CTs ratio 2400/1 Class X or equivalent
		iii)	3 overcurrent and earth fault CTs ratio 3200/1 Class 5P
		iv)	3 bus zone, differential CT's of ratio 1600/1 Class X
		v)	3 bus zone differential check CT's of ratio 1600/1 Class X 33KV/110V 3 phase voltage transformer suitable for instruments, automatic voltage regulatory, protection, synchronising and metering.

B	8	a)	Feeder panels each equipped as for panel A (a), except for 630 A circuit breaker and cable box suitable for 3 core 300 sq. mm copper XLPE steel wire armoured cables
		b)	Current transfoemr:-
		i)	3 overcurrent and earth fault and metering CT's ratio 400/1
		ii)	3 CT's suitable for distance protection ratio 400/1 for overhead line feeders and pilot wire protection for U/G cable feeder
		iii)	3 bus zone differential CT's ratio 1600/1
		iv)	3 bus zone check CT's ratio 1600/1
C	2	a)	Panels each equipped as for panel type A (a) except for 630A breaker and cable box suitable for 3 core 300 sqmm copper XLPE steel wire armoured cables
		b)	Current transformers: – 3 Overcurrent and earth fault and metering CT's ratio 400/1 – 3 current transformers for differential proteciton 400/1 ratio Class X – 3 bus zone differential CT's of ratio 400/1 – 3 bus zone check CT's of ratio 1600/1.
D		a)	Panel equipped as for panel Type ''A"
		b)	One set of 3 current transformer 1600/1A for overcurrent protection and metering
	2		Busbar 33KV/110 volt voltage transformers for instrumentation and feeder distance protection.

General

Future Panels (2 at the end of each switchboard) building and related works only for future use.

2.2 Control Board for 33KV Switchgear

A 2 Control equipment for 63MVA transformer type A comprising:

Section of mimic diagram, circuit breaker control discrepancy type switch, discrepancy type position indication for 33KV isolators and 33KV neutral isolators.

1 – ''Springs charged" blue indication lamp
1 – ''Trip circuit healthy" white indication lamp
1 – ''Fault trip" amber indication lamp
1 – Remote/Supervisory selector switch
1 – Ammeter selector switch
1 – Ammeter scaled 0-1600A
1 – Voltmeter scaled 0-40KV with fuses

1 – Push button for "dead busbars" closing
1 – Socket for synchronising equipment
1 – Synchronising selector switch
Wiring, cable glands, fuses, links, terminal blocks, terminals, labels etc. to complete.

B/C/D

Control equipment for Feeder type B comprising:

Section of mimic diagram including circuit breaker control discrepancy type switch,
discrepancy type position indication for 33KV isolators

1 – "Spring charged" blue indication lamp, if applicable
1 – "Trip circuit healthy" white indication lamp
1 – "Fault trip" amber indication lamp
1 – Remote/Supervisory selector switch
1 – Ammeter selector switch
1 – Ammeter scaled 0-300A and 0-600A on reverse side for type B/C and 0-1000A and 0-2000A for type D feeder
– Wiring, cable glands, fuses, links, terminal blocks, terminals, labels etc. to complete.

General 2

Busbar voltmeters scaled 0-40KV with fuses.

1

Hinged panel mounted in a suitable location on the control board complete with synchroscope, synchronising lamps, voltmeters, switches, wiring, labels etc.

2.3 Relay Panels for 33KV Switchgear

Circuit Type	Quantity	Description
A	2	Relay panel for each 63MVA transformer equipped with:-

1 – Overcurrent and earth fault relays with three IDMT overcurrent elements and
one IDMT earth fault element.

Relay setting ranges:
– Overcurrent IDMT 50 – 200%
– Earth fault IDMT 10 – 40%

1 – Transformer biased differential relay
1 – Restricted earth fault high impedence relay (33KV)
1 – Tripping relay
1 – Buchholz auxiliary flag relay
1 – W.T. auxiliary flag relay
1 – 2 Stage standby earth fault relay (33KV)
1 - Auto circuit supervision relay

		1 – Trip circuit supervision relay – Wiring, fuses, links, terminal blocks, terminals, C.T. test blocks with shorting/ isolating links, labels etc. to complete. 1 – HV interposing CT for transformer differential protection 2 – LV interposing CTs for transformer differential protection
B	8	Relay panel for feeder type B equipped with: 1 – Overcurrent and earth fault relay with three IDMT overcurrent elements, and one IDMT earth fault element Relay setting ranges: – Overcurrent IDMT 50 – 200% – IDMT earth fault 10 – 40% 1 – Distance Protection Relay or Pilot wire protection relay with associated receive and send relays. Pilot wire supervision equipment. 1 – Tripping relay 1 – Trip circuit supervision relay Wiring, fuses, links, terminal blocks, cable glands, CT test blocks with shorting/isolating links, labels etc. to complete.
C	2	1)Overcurrent and earth leakage relays. i) Overcurrent IDMT 50 to 200% (three elements) ii) Earth leakage instantaneous 10 to 40% 2) Master trip relay for tripping 33KV and 11KV circuit breaker for controlling transformers.
D	1	Relay panel for feeder type D equipped with: 3 Pole overcurrent and three over IDMT relays 50 – 200%
General	1	Busbar protection panel for 33Kv switchgear protection including relays, switches, indicating lamps, CT test/isolating links, wiring, terminal blocks, terminals, fuses, links, labels etc.

3.0 Tap Changer, Metering and Alarm Panels

Tap Changer Control panels including automatic voltage regulator, control ''raise" and ''lower" push buttons, ''tap change in progress" lamps, ''tap change in progress" buzzer, tap position indicator, voltmeter, and all necessary equipment for the provision of a master-follower tap change control scheme between the 63MVA transformers.

Metering for 63MVA Transformer 33KV Circuits

1 – Metering panel complete with all necessary terminals, terminal blocks, glands, connectors, wiring, trunking, CT test/isolating links etc. for incoming 33KV metering circuits for 63MVA transformers including:

i) 2 – Kwh meters including maximum demand indication.
ii) 2 – KVArh meters including maximum demand indication.
iii) 1 – Set of summation equipment including printometer as specified in Section 7.4
iv) 1 – 110 Volt DC time clock for measuring half hour intervals.

Alarm Panel

1 – Alarm panel, including facias for general substation alarms, transformer alarms etc. flasher relay, bell, buzzer, switches, wiring, terminals, fuses, links and all necessary equipment to provide alarm system specified in Section 4.6.

The following alarms shall be included on the facias:

Transformer No. 1

Buchholz alarm
Buchholz trip
Winding temperature alarm
Winding temperature trip
Cooler supply fail
Tap changer out of step
Main protection operated
Back-up protection operated
Tap-changer supply fail
V.T. fail

Transformer No. 2

As for Transformer No. 1

General:

Trip supply fail
Battery fault (110 volt)
132KV circuit breaker tripped
33KV circuit breaker tripped
Fire alarm
132KV busbar protection operated
33KV busbar protection operated
LV AC fail (essential services)
Battery fault (48 volt)
132KV distance protection operated
33KV distance protection operated

4.0 TRANSFORMERS

Transformers shall comply with the requirements of Section 5.0

Description		(a) Power Tx. 63 MVA	(b) Earthing Tx. 315 KVA
Quantity		2	2
Number of Phases		3	3
Normal ratio or Transformation KV		132/33	33/0.415
Max. continuous rating (See Cl. 4.1.4)		63MVA	315KVA
Vector Group Reference		Yd 5	Zn Yn 11
Type of cooling (See Cl. 4.1.3)		ONAN/ONAF	ONAN
Range of Tx. taps	%	-15% + 5%	± 5%
Size of transformation ratio steps		1.1%	2.5%
Terminal arrangements:			
– 132KVx		Cable Box	–
– 132KV Neutral		Bushing	–
– 33KVx		Cable Box	Cable Box
– 33KV Neutral		–	Bushing
– 415 volts		–	Cable Box
Impedance voltage at 75 Deg. C and CMR at normal 17 – 20% rating between HV and LV windings approx.			
Supply voltage for control circuits	Vdc	110	–
AVR ref. voltage	Vdc	110	–
Zero sequence impedance (earthing transformer)			5 Ohms/phase
System highest voltages	KV	145/36	36/0.433
Min. withstand voltages full wave impulse KV		650/170	170/-
Induced over voltage	KV	230/70	70/-
Power frequency withstand of neutral	KV	40/-	40/-
Type of transformer base required		skid or flat	skid or flat
Whether anti-vibration pads required		Yes, if flat base	Yes, if flat base
Rating of interconnected star winding on 30 sec. basis neutral	Amps		1500
132KV Neutral current Tx. for neutral fault (ratio 300/1 accuracy Class 5P) and restricted earth fault protection (ratio 300/1 Class X) to be incorporated in the 132KV neutral bushing		One set on each Tx.	

5.0 415 VOLT SWITCHBOARDS, LIGHTING AND SMALL POWER

5.1 Main Distribution Board for 415/240 volt substation services. The board shall include manually operated switch fuse units for incoming circuits from 33/0.415KV transformers, bus section isolator interlocked with incoming switch fuse units, switch fuse units for outgoing supplies from each bus section to the essential service board, miniature circuit breakers or fuses for lighting and small power circuits, ammeter and associated current transformers on each incoming circuit, voltmeter with voltage selection switch on each section of busbar, labels etc.

5.2 Essential Services sub-distribution board. The board shall include an automatic changeover contactor, incoming supply isolator, no volt relay, ammeter and associated current transformer, voltmeter, miniature circuit breakers or fuses for essential services circuits, labels etc.

5.3 Complete set of lighting and small power equipment for the substation including outside lighting, emergency lighting, socket outlets, TPN outlet suitable for Oil treatment plant to be supplied under Schedule E, tools and appliances, wring etc. to comply with Section 11.00 of the specification.

5.4 Air conditioning for 33KV switchgear room, control/relay room and powr line carrier rooms.

5.5 Ventilation for toilet, battery room LVAC room to comply.

6.0 BATTERIES, CHARGERS AND D.C. SWITCHBOARDS

6.1 Set of two 110 volt 100% duty nickel cadmium batteries, control and charging equipment and one DC distribution board.

Control and charging equipment shall include an automatic float charger and boost charger. Each charger shall be complete with a switch fuse for incoming AC supplies and either an off load isolator or disconnecting links for the DC output, incoming AC indicating lamp, input voltmeter with low voltage alarm contact, output ammeter, voltage failure detecting device etc.

6.2 DC distribution board shall include double pole switches and fuses for outgoing DC circuits, double pole isolators for incoming DC supplies, voltmeter and centre zero ammeter on each incoming battery circuit, earth fault detecting relays, battery low voltage alarm device, double pole changeover contactors etc.

7.0 EARTHING

Complete earthing system as required in the specification including connections to all equipment supplied under this contract and to any existing earthing at the substation.

8.0 FIRE FIGHTING EQUIPMENT

8.1 2 – Wall mounted 10KG portable dry powder extinguishers each provided with 4 re-chargers for control/relay room.

8.2 2 – Wheeled trolley type 50KG dry powder extinguishers provided with 4 re-chargers.

8.3 1 X 10 KG dry powder wall mounting extinguishers.

8.4 Water sprinklers for transformer fire protection.

9.0 CABLES AND TERMINATIONS

The following cables and terminations shall be included and installed as necessary to complete the works in accordance with Section 13.0 of the specification.

Item	Description
9.1	33KV XLPE cable between 63MVA Transformer Nos. 1 and 2 and 33KV Switchboard Cables shall be 1 x single core per phase 630sq.mm XLPE insulated as per conductor.
9.2	33KV Cables between 63MVA Transformer Nos. 1 and 2 the appropriate earthing transformer. Cables shall be 185 sq.mm single core copper conductor XLPE.
9.3	1000 volt cables between auxiliary earthing transformers and main distribution board. Cables shall be: – 300 sq.mm copper conductor. – XLPE insulated and sheathed armoured 4 core or equivalent single core cables.
9.4	1000 Volt cables between main distribution board and sub-board for essential services. Cables shall be 70 sq.mm copper conductor XLPE insulated and PVC sheathed non-armoured 4 core cable.
9.5	Multi core and telephone cables to complete control, alarm, indication and tele-communication circuits etc.

10.0 POWER LINE CARRIER EQUIPMENT

Item	Description
	10.1Power Line Carrier Equipment (sending end substation – New S.S)
	A Outdoor Equipment
	Inter circuit phase/phase coupling to Incoming No. 1 and No. 2 132 KV lines.
	2 – 1250 Amp line trap complete with all necessary fittings, clamps etc. for mounting on the 132KV coupling capacitor.
	2 – 132KV coupling capacitor complete with all fittings for mounting the line traps on top.
	2 – Galvanised steel frame work mounted on terminal tower cross arms for supporting the coupling capacitors.
	2 – High frequency coupling units complete with coupling filters and protection circuits with all necesary mounting details.
	High frequency cable to connect the HF coupling units with the associated PLC terminals.
	B Indoor Equipment
	2 – Carrier terminal equipment comprising signal generators, modulators, line amplifiers, filters, speech circuits, telephone signalling (dialling) and bandwidth for teleprotection as necessary and future telecontrol from supervisory control centre
10.2	**Power Line Carrier Equipment New S.S. – S.S. at the end of the feeder**

A Outdoor Equipment

Inter-circuit phase/phase coupling to outgoing Feeder No. 1 and No. 2 132KV lines.

2 – 800 Amp line trap as item 11.1 A.
2 – 132KV coupling capacitors as item 11.1 A.
2 – Galvanised steel framework as item 11.1 A.
2 – HF coupling units as item 11.1 A.
HF cable as item 11.1 A.

B Indoor Equipment

2 – Carrier terminal equipment as item 11.1B to S.S. at the other end of outgoing feeder.

10.3 Automatic Telephone Equipment

1 – Private automatic telephone exchange (PAX) equipped initially for 20 local extensions, 4 links and 6 trunk terminating units sending end substation and to the S.S. at the end of outgoing feeder.

8 – Telephone instruments
1 – Main distribution frame

10.4 Telecontrol Equipment

1 – Set of VF transmit equipment to code and transmit found alarm signals to supervisory tron-centre (one urgent, one nonurgent and spare)

10.5 Teleprotection Equipment

2 – Sets of duplex ''direct tripping" high speed teleprotection equipment to directly trip the 132KV circuit breakers at sending end from the Distance Protection at new substation and to trip the 132KV circuit breakers at new S.S. from the protection at sending end station.

2 – Set of duplex ''direct tripping" high speed teleprotection equipment to directly trip the 132KV circuit breaker at new substation in the event of transformer fault at other end of the outgoing feeder and to trip the 33KV circuit breakers at substation on the end of the outgoing feeder from the distance protection of new substation.

10.6 Power Supplies

2 – Battery of sufficient capacity for the equipment requirements including future circuits together with battery stand.

2 – Set of battery charger equipment of sufficient rating for the above battery together with the necessary distribution panel.

SCHEDULE – "B"
TECHNICAL PARTICULARS AND GUARANTEES

1.0 132KV OUTDOOR EQUIPMENT

Item	132KV
a) Surge Arrestors	
Manufacturer	
Type of Arrestor	
Class and Duty	
Rated Voltage	RMS KV
Rated Current	KA
50Hz sparkover voltage	RMS KV
100 percent impulse sparkover on 1.2/50 micro second wave	Peak KV
100 percent impulse sparkover on AIEE steep fronted wave	
Discharge residual voltage based on 10/20 wave at:	
A) 5KA	Peak KV
B) 10KA	Peak KV
C) 20KA	Peak KV
Current discharge capacity:	
A) 5/10 second wave	Peak KV
B) 2000 second rectangular wave	Peak KV
Minimum reseal voltage	RMS KV
Total height of arrestor	mm
Total weight of arrestor	kg
Type of surge counter	
Power Frequency withstand capability for:	
A) 1 Sec	RMS KV
B) 3 Sec	RMS KV
C) 10 Sec	RMS KV
D) Continuous	RMS KV
Minimum creepage	
Distance per unit	
Specified	MM
Guaranteed	MM
b) Cable Sealing End – Bushing Insulators	
Maker	
Insulator material	
Maker's type reference and rated voltage	
Pitch circle diameter and drilling of flange	mm approx.
Length of insulator (overall)	mm

Weight of insulator
Electristatic capacity of complete bushing
50Hz dry voltage withstand
Lightning impulse flashover voltage (1/2/50 Wave)
Full wave lightning impulse voltage withstand
50 Hz wet withstand voltage without arcing horns
Total creepage distance of shedding (see Cl. 4.7.1)
Protected creepage distance of shedding

2.0 132KV OUTDOOR SWITCHGEAR
A) 132KV CIRCUIT BREAKERS

Manufacturer
Type Number
Class (Vaccum or S F6)
Number of phases
No. of pole units per complete equipment
Frequency
Rated voltage
Impulse withstand on 1.2/50 as wave
Power frequency withstand voltage
Normal current rating(s)

Type Tests etc.

Short time current rating:-
A) One second
B) Three seconds

Breaking capacity:-
A) Symmetrical
B) Asymmetrical

Testing Authority
Test Certificate Report – reference
Short circuit making current
Rated operating duty cycle
First phase to clear factor
Rated transient recovery voltage at 100% rated short circuit breaking current
Rate of rise to which tested
Rate of rise to which be prepared to test
Rated inductive breakng current
Rated line charging breaking Current
Rated cable charging breaking current
Rated out of phase breaking current
Rated characteristic for short line faults
Circuit breaker re-strike free
Max. guaranteed switching over voltage
Trip coil current
Trip coil voltage

Is the circuit breaker trip free?	
Type of arcing contacts of arc	
Material of contact Surfaces	
Number of breaks per phase	
Length of each break	mm
Length of stroke	mm

Dimensions etc.

Weight of whole circuit breaker equipment with oil (if any) and all fittings as in service	Kg
Max. shock load imposed on floor or foundation when opening under fault conditions (state whether tension or compression)	Kg
Max. pressure rise in circuit breakers due to the making of breaking of rated currents	KN/m2
Routine pressure test on circuit breaker tanks or containers	KN/m2
Pressure type test on circuit breaker tanks or containers	KN/m2
Interrupting gas pressure (Normal) at 20 Deg. C	KN/m2
Limits of gas pressure at 20 Deg. C.	
– Max	KN/m2
– Min	KN/m2

Operating Particulars

Opening times:-

A) Without current	m.sec
B) At 100% of rated breaking current	m.sec
Max. arcing time of any duty cycle	m.sec
Current on which maximum arc duration occurs	A
Closing time	m.sec
Minimum time from arc extinction to contact remake for auto reclosing	m.sec
Time from closing of control switch to completion of closing stroke when making current	m.sec

Constructional Features

Is an external series break incorporated in breaker?	YES/NO
Is any device used to limit transient recovery voltage?	YES/NO
Method of closing	
Method of tripping	
Solenoid closing coil current	A
Solenoid closing coil voltage	Vdc
Rated voltage for closing spring winding motor or compressor pump meter	V
Normal air or fluid pressure for operation of closing mechanism	KN/m2
Closing release coil current	A
Closing release coil voltage	V
Minimum clearances in air:-	
a) Between phases	mm
b) Phases to earth	mm
c) Across circuit breaker poles	mm
d) Live part to ground level	mm
Min. clearances in oil or other extinguishing mediums:-	

a) Between phases
b) Phases to earth
c) Between live parts of one phase mm
Material of tank or container
Material of moving contact tension rod
Loading of heaters for circuit breakers KW
Period of time equipment has been in commercial operation Years

B) 132KV CIRCUIT BREAKER INSULATORS

Manufacturer
Function of insulator
Rated service voltage KV
Principal insulating materials
Length of insulators overall mm
Shed profile drawing no. (to be enclosed with tender)
Weight of insulator complete with fittings kg
Material of fittings
Total creepage distance over porcelian externally:
Specified mm
Guaranteed mm
Protected leakage distance over porcelain externally mm
Voltage below which no corona shall be visible KV
Number of compressors
Type of air compressor
Motor rating KW
Weight of each complete compressor unit Kg
Total storage capacity of unit air receivers of each three phase circuit breaker at working pressure m3
Time to restore to 95% normal operating pressure to each unit air receiver after discharge to minimum lockout pressure min
Number of close/open operations per circuit breaker from normal pressure of unit receiver without any make-up air
Number of common receivers
Storage capacity of common receiver at working pressure m3

Normal operating pressure at 20 Dec. C:
a) Common receivers KN/m2
b) Unit receivers KN/m2

Max. operating pressure at 20 Deg. C:
a) Common receivers KN/m2
b) Unit receivers KN/m2

Min. operating pressure at 20 Deg. C:
a) Common receivers KN/m2
b) Unit receivers KN/m2

Pressure at which safety valves reset:
a) High pressure system KN/m2

b) Common receivers	KN/m2
c) Unit receivers	KN/m2

OUTDOOR 132KV SWITCHGEAR
132KV ISOLATORS AND EARTHING SWITCHES

ITEM	
Manufacturer	
Type No. (See brochure OJY IGB 79-05/83-09)	
Nominal service voltage	KV
Switchgear rated voltage	KV
Number of breaks per pole	
Number of poles per complete unit	
Min. impulse withstand on 1.2/50 us wave	KV
Power frequency withstand voltage	KV
Normal rated current	A
Max. short time current rating:	
a) One second	KA RMS
b) Three seconds	KA RMS
Short circuit making current	Peak KA
Type of contacts	
Material of contact surfaces	
Total weight of three phase isolator complete	kg
Total weight of single phase isolator complete	kg
Air gap between poles of one phase	mm
Charging current breaking capacity	A
Magnetising current breaking capacity	A
Type of operating mechanism	
Motor rating	W

Creepage distance of insulators:

Manufacturer (See Specification No. N-24368 Type DFA-95927M)	
Specified	mm
Guaranteed	mm
Protected creepage distance over porcelain externally (90 Deg. shadow)	mm
Voltage below which no corona shall be visible	KV
Dry flashover voltage with all fittings	KV
Wet flashover voltage with all fittings	KV
Routine over-voltage test (one min. power frequency)	KV
Thermal stability test voltage	KV
Min. dry withstand voltage (momentary frequency not applicable to bushing)	KV
Min. puncture or oil immersed withstand voltage (momentary power frequency)	KV

132KV Outdoor Busbars and Connections

Manufacturer	
Material	
Overall diameter of main connections	mm
Nomainal section of main connections	mm2

Cross section and make-up of main connections	
Max. rated current of main connections (At ✘ 50 Deg. C)	Amperes
Max. working tension of main connections	N/mm2
Resistance of conductors per 100m at 20 Deg. C	Ohms
Tension breaking stress material	N/mm2
Max. permissible span length	m
Max. sag under own weight of maximum span	mm
Type of expansion joint	
Type of bi-metal connector	
Overall diameter of earthing and subsidiary connections	mm
Nominal section of earthing and subsidiary connections	mm2
Cross section and make-up of earthing and subsidiary connections	

132KV Outdoor Post Type insulators

Manufacturer	
Insulator material	
Maximum working vertical load (tension and compression)	N
Vertical breaking laod (tension)	N
Ultimate tensional load	N-m
Maximum horizontal working load	kg
Mechanical routine test load (tension)	N-m
Electrical and Mechanical type test load (tension)	N
Mechanical type test load (tension)	N
Greater diamter	mm
Weight of complete post	kg
Electrostatic capacity	F
Min. 50Hz dry flashover voltage complete with fittings	KV
Min. 50Hz wet flashover voltage complete with fittings	KV
Min. 50Hz puncture voltage	KV
Impulse withstand voltage 1.2/50 micro second wave	KV
Total creepage distance of shedding	
Specified	mm
Guaranteed	mm
Protected creepage distance of shedding	mm
Material of fitting	

132KV Insulator Strings

Insulator type	
Number of units per string	
Distance between centres of units	mm
Length of string overall	mm
Maximum working load	N
Breaking load per unit	N
Mechanical routine test load	N
Electro-mechanical type test load	N
Mechanical type test oad	N
Outside diameters of units	mm
Electro-static capacity of unit	mfd

Weight of complete string	kg
Min. 50Hz dry flashover voltage of unit	KV
Min. 50HZ wet flashover voltage of unit	KV
Min. 50Hz puncture voltage	KV
Impulse withstand voltage of string 1.2/50 micro second wave	KV
Total creepage distance of shedding Specified	mm
Guaranteed creepage distance of shedding	mm
Material of fittings	mm

132KV Current Transformers

Manufacturer	
Rated service voltage	KV
Principal insulating materials	
Length of insulator overall	
Weight of insulator complete with fittings	KG
Max. external diamter of ring type current transformer which can be accommodated	mm
Max. axial length available for current transfoermer accommodation	mm
Electrostatic capacity of complete bushing or current transformer	pF
Gap between arcing horns	
Material of arcing horns	
Material of fittings	
Total creepage distance over porcelain externally:	
Specified	mm
Guaranteed	mm
Protected creepage distance over porcelain externally (90 Deg. shadow)	mm
Dry flashover voltage with all fittings	KV
Wet flashover voltage with all fittings	KV
Routine over-voltage test (1 min. power frequency)	KV
Thermal stability test voltage	KV
Min. dry withstand voltage (momentary frequency not applicable to bushing)	KV
Voltage below which no corona shall be visible	KV
Min. impulse withstand (1.2/50 micro sec. wave) crest	KV
Min. puncture or oil immersed withstand voltage (momentary power frequency)	KV

132KV Outdoor Surge Arrestors

Manufacture	
Type of arrestor	
Class and duty	
Rated voltage	RMS KV
Rated current	KA
50HZ sparkover voltage	RMS KV
100% impulse sparkover on 1.2/50 micro second wave	Peak KV
100% impulse sparkover on 940KV/used steep-fronted wave	Peak KV
Discharge residual voltage based on 8/20 micro second wave at:	
a) 5 KA	Peak KV
b) 10 KA	Peak KV
c) 20 KA	

Current discharge capacity:

a) 5/10 micro second wave	Peak KV
b) 2.000 micro second rectangular wave	Peak KV
Minimum reseal voltage	RMS KV
Total height of arrestor	mm
Total weight of arrestor	KG
Type of surge counter	
Total creepage distance:	
Specified	mm
Guaranteed	mm

132 KV Capacitor Voltage Transformers

Manufacturer	
Rated service voltage	KV
Principal insulating materials	
Length of insulator overall	mm
Weight of insulator complte with fittings	kg
Electrostatic capacity of complete bushing	mfd
Gap between arcing horns	mm
Material of arcing horns	mm
Material of fittings	
Total creepage distance over porcelain externally:	
Specified	mm
Guaranteed	mm
Protected creepage distance over porcelain externally (90 Deg. shadow:	mm
Dry flashover voltage with all fittings	KV
Wet flashover voltage with all fittings	KV
Routine over-voltage test (1 min. power frequency)	KV
Thermal stability test voltage	KV
Min. dry withstand voltage (momentary frequency not applicable to bushing)	KV
Voltrage below which no corona shall be visible	KV
Min. impulse withstand (1.2/50 micro sec. wave) crest	KV
Min. puncture or oil immersed withstand voltage (momentary power frequency)	KV

3.0 33KV INDOOR SWITCHGEAR

ITEM

Manufacturer	
Type Number	
Class (i.e. SF6/Vacuum)	
Number of phases	
Rated Design Voltage	KV
Impulse withstand on 1.2/50 microsec wave	KV
Frequency	Hz
Normal busbar current rating (site)	A
Overload rating (emergency) % of normal	
Duration in any 24 hour period hours Ambient Temp. *C	

Voltage Transformers

Manufacturer	
Type	
Rated burdern per phase	VA
Class	
Maximum ratio error with rated burdern and 5% normal primary voltage	%
Maximum phase angle error with rated burden and 5% normal primary voltage	Deg.
Total weight of 3 phase unit	Kg
Total weight of 1 phase unit	Kg

Current Transformers

Manufacturer	
Type	
Circuit/Functions	
Ratio	
Accuracy Class	
Rated short time thermal current 3 sec	KA
Rated accuracy limit factor	
(applicable for metering circuits)	

Busbars

Maximum temperature rise at rated busbar current (site)	Deg. C
Material used for busbar	
Cross section of busbar	mm2
Insulation material	

Type Tests

Short time withstand current of switchgear:

A) One second	RMS KA
B) Three Second	RMS

Breaking capacity:

A) Symmetrical	RMS KA
B) Asymmetrical	RMS KA

Rated short circuit making current	Peak KA
Rated cable charging current	A
Rated capacitor breaking current	A
Rated inductive breaking current	A
Rated line charging current	A

Operating Particulars

Opening time:

A) Without current	ms
B) At 100% of rated breaking current	ms

Maximum arc duration of any duty cycle	ms
Duty cycle on which maximum arc duration occurs	%
Making time	ms
Minimum time from arc extinction to contact remake when adapted for auto reclosing	ms
Time of arc duration	ms
Time from closing of control switch to completion of closing stroke with making current	ms

Constructional Features

Method of closing	
Method of tripping	
Rated voltage for sping winding motor for closing	Vdc
Spring winding motor current	A
Closing release coil current	A
Closing release coil voltage	Vdc
Trip coil current	A
Trip coil coltage	Vdc
Is the circuit breaker trip free	
Type of arcing contacts or arc control device	
Type of main contact	
Material of contact surfaces	
Number of breaks per phase	
Length of each break	
Length of stroke	

Dimensions etc.

Weight of circuit breaker unit complete	Kg
Weight of whole circuit breaker equipment and all fittings as in service	Kg
Maximum shock load imposed on floor or foundations when opening under fault conditions (state whether tension or compression)	Kg
Maximum pressure rise in circuit breaker due to making or breaking or rated current	N/m2
Routine pressure test on circuit breaker containers	N/m2
Pressure type test on circuit breaker containers	N/m2
Minimum clearances in air:	
A) Between phases	mm
B) Phase to earth	mm
C) Across circuit breaker poles	mm
Minimum clearances in oil:	
A) Between phases	mm
B) Phase to earth	mm
C) Across circuit breaker poles	mm
Minimum clearances in oil:A) Between phases	mm
A) Between phases	mm
B) Phase to earth	mm
C) Between live parts of one phase	mm

Item

Material of container

Material of moving contact tension rod		
Loading of heaters for circuit breakers		W
Details of floor plates or rails – if provided		
Overall dimensions of each circuit breaker unit: 33KV		
A) Height		mm
B) Length		mm
C) Width		mm

4.0 TRANSFORMERS

Description	**Item**	**315KVA 33/.415100**
Type of cooling		
On-load voltage control equipment		
A) Type		
B) HV or LV winding		
C) Range on-load	%	
D) Power frequency with stand test voltage IEC 214:1976 between first and last contacts of the selector switch	KV	
Between any two adjacent contacts of the selector	KV	
Between open divertor switch contacts	KV	
E) Type test certificate reference		
Size of tapping step	%	
Approx. ONAN rating of forced cooled Tx.	MVA	
Hot spot temperature at CMR under service conditions stated in schedule	Deg. C	
Max. top oil temperature (average daily ambient air temperature 30 Dec. C)		
A) C.M.R.	Deg. C	
B) On rating	Dec. C	
Max. flux density in iron at normal voltage and frequency and at normal ratio		
A) Cores	Tesla	
B) Yokes	Tesla	
Magnetizing current		
(approx) no-load losses		
(excluding cooling plant losses) at rated voltage ratio and frequency	KW	
Cooling plant losses at C.M.R.	KW	
Load losses at 75 Deg. C and normal ratio:		
A) C.M..R	KW	
B) ONAN rating	KW	
Total losses at 75 Deg. C and normal ratio:		

A) C.M.R. including input to cooling plant KW
B) ONAN rating KW

Regulation at 75 Deg.C/ and normal ratio:

A) At unity power factor %
B) At 0.9 lagging power factor %

Maximum current density in winding at C.M.R.

A) HV Winding A/mm2
B) LV Winding A/mm2

Description	**Item**	**63MVA 132/33KV**
Assumed simultaneous operating conditions under which maximum flux density is attained		
Frequency	Hz	
Voltage HV	KV	
LV	KV	
Load MVA at 0.8 pf lagging		
Maximum flux density in iron under these conditions	Tesla	
Impedance voltage at 75 Deg. C and CMR between:		
H.V. and L.V. windings at highest transformation ratio	%	
H.V. and L.V. windings at lowest transformation ratio	%	
Temperature rise of windings at CMR above specified design ambient		

The tenderer shall enter the terminal voltages appropriate to the stated loading in accordance with IEC 354 : 1972 and the impedance offered.

TRANSFORMERS

Details of Construction

Types of winding:

A) H.V.
B) L.V.

Insulation of:

A) H.V. Winding
B) L.V. WInding

Insulation of tapping connections
Insulation of:

A) Core bolts
B) Side plates
C) Core laminations

Winding connections brazed or crimped
Is facility provided for adjustment of axial pressure on windings — Yes/No
Thickness of transformer tank

A) Sides — mm
B) Bottom — mm

Material used for gaskets for oil tight joints

Radiators and Fans

Thickness of radiator plates and/or cooling tubes — mm
Equipment for ON cooling state (A) or (B)

A) Radiators on main tank
B) Separate cooler banks

Auxiliary equipment for ONAF cooling – state (A) or (B)

A) Forced air cooling of radiators on tank
B) Separate forced air cooler bank

Number of coolers/radiators or cooler banks per transformer
Thermal rating of each cooler/ radiator bank — KW
Number of air blowers per Tx. Speed of air blowers — RPM
B.S. rating of each air blower motor — KW
Starting current of each blower motor — A

Oil Volumes and Weights

Total oil required including cooler system — litres
Volume of oil above level of the top yoke — litres
Total volume of conservator — litres
Volume of oil in tap changer — litres
Volume of oil in coolers — litres
Volume of oil in conservator between highest and lowest visible — litres
Weight of core and winding assembly — KG
Weight of tap changer gear — KG
Weight of OLTC and compartment — KG
Weight of cooling equipment complete — KG
Weight of conservator tank — KG
Total weight of largest section arranged for transport — KG
Total weight of transformer for operation but excluding weight of coolers if these are not supported on transformer tank (including oil) — KG
Overall dimensions of transformers complete with tap changer gear:
Width — mm
Length — mm
Height — mm

5.0 PROTECTON, METERING AND CONTROL

Description

A) 132KV Distance Protection

Manufacturer
Type of relay and measuring system
Minimum setting for near and fault:

Single phase to earth
Phase to phase
Three phase

Maximum setting for faults at remote end:

Single phase to earth
Two phase to earth
Phase to phase
Three phase

Minimum length of transmission line which can be protected KM
Maximum length of transmission line which can be protected KM
Maximum time delay between initiation of fault in first zone and energing of the trip circuit:

a) At a current equal to CT rating
b) At a current equal to five time CT rating
c) At a current equal to 20 times CT rating

Range of adjustment for time delay relays

a) Second zone
b) Third zone

Burden imposed by protective equipment:
Resistive –

a) Current circuits (at 20 times CT rating) VA
b) Voltage circuits (at normal rated voltage) VA

Reactive –

a) Current circuits (at 20 times CT rating) VA
b) Voltage circuits (at normal rated voltage) VA

B) 132KV Busbar Protection

Manufacturer
Type of equipment (solid state/electro-mechanical)

Minimum sensitivity:

A) Earth faults — % of C.T. rating

B) Phase faults — % of C.T. rating

Maximum through fault stability

Operating time fault initiation to trip initiation at:

A) Current 3 times minimum setting — milli secs.

B) Current 10 times minimum setting — milli secs.

C) **Transformer biased differential protection**

Manufacturer

Type of description of system

Range of operating coil settings — % of C.T. rating

Range of bias coil settings — % of C.T. rating

Recommended operating coil setting

Recommended biased coil setting

Sensitivity for earth faults at recommended settings:

A) Least sensitive phase — % of C.T. rating

B) Most sensitive phase — % of C.T. rating

Sensitivity for phase faults at recommended settings:

A) Least sensitive phase — % of C.T. rating

B) Phase faults — % of C.T. rating

Maximum through fault at which the protective equipment is stable with recommended settings:

A) Earth faults — % of C.T. rating

B) Phase faults — % of C.T. rating

Maximum time delay between initiation of fault and energing of breaker trip current — milli secs

Details of magneting in rush current bias unit for stability of protection under switching surges

D) **Transformer restricted earth fault protection**

Manufacturer

Type of relay

Sensitivity — % of C.T. rating

Magnitude of external phase or earth fault up to which the protection is stable — % of C.T. rating

Burden for current transformer — VA

Time delay between initiation of fault and energising of breaker trip coil at twice minimum setting — milli secs

Time delay between initiation of fault and energising of breaker trip coil at 10 times CT rating — milli secs

E) Inverse Time Overcurrent and Earth Fault Protection

Manufacturer
Type of relay
Range of current settings:

A) Overcurrent elements	% of C.T. rating
B) Earth fault elements	% of C.T. rating
C) High set instantaneous elements	% of C.T. rating
Range of timing setting sat 10 times C.T. rating	Secs
Burden of relay at 10 times C.T. rating	VA

F) Standby Earth Fault Protection

Manufacturer
Type of relay
Type of time delay realy

Range of fault settings	% of C.T. rating
Range of setting of definite time delay relay:	
A) First stage	Secs
B) Second stage	Secs
Burden of relay at 10 times C.T. rating	
Percentage of current setting at which relay will reset	%

G) 33KV Distance Protection Relays

Manufacturer
Type of relay and measuring system
Type of starting system
Maximum setting for near end fault:

Single phase to earth
Phase to phase
Three phase
Two phase to earth

Minimum setting for faults at remote end:

Single phase to earth
Two phase to earth
Phase to phase
Three phase

Minimum length of transmission line which can be protected	KM
Maximum length of transmission line which can be protected	KM

Maximum time delay between initiation of fault in first zone and energing of trip circuit:
a) At a current equal to CT rating

b) At a current equal to five times CT rating
c) At a current equal to 20 times CT rating

Range of adjustment for time delay relays

a) Second zone
b) Third zone

Burden imposed by protective equipment:
Resistive –
a) Current circuits (at 20 times CT rating) VA
b) Voltage circuits (at normal rated voltage) VA

Reactive –

a) Current circuits (at 20 times CT ratings) VA
b) Voltage circuits (at normal rated voltage) VA

H) **33KV Busbar Protection**

Manufacturer
Type of equipment (solid state/electro mechanical)
Minimum sensitivity:

A) Earth faults % of C.T. rating
B) Phase faults % of C.T. rating

Maximum through fault stability.
Operating time fault initiation to trip initiation at:

A) Current 3 times minimum setting milli secs.
B) Current 10 times minimum setting milli secs.

I) **Neutral Earth Fault Protection**

Manufacturer
Type of relay
Type of time delay relay
Range of fault settings % of C.T. rating
Range of setting of definite time delay relay Secs
Burden of relay at 10 times C.T. rating VA
Percentage of current setting at which relay wil lreset

Signature : .....

Designation : .....

Name of Tenderer : .....

Date : .....

AUXILIARY AND EARTHING TRANSFORMERS

Description	Item	Earthing Tx. 33/0.415 KV
Current density in interconnected star winding with specified fault current	A/mm2	
Current density in interconnected star winding at 3 second rating	A/mm2	
Continuous earth faulth current rating	A	
CMR of lower voltage star winding	KVA	
Impedance voltage at CMR of lower voltage winding between HV and LV wining v	%	
Resistance of higher voltage winding at 75 Deg. C.	Ohms per phase	
Zero phase sequence impedance at 75 Deg. C with LV windings open circuited	Ohms per phase	
Total oil required	litres	
Weight of complete transformer (including oil)	Tonnes	
Overall dimensions of transformers:		
Width	mm	
Length	mm	
Height	mm	
Time Switch		
Type (Electronic/Mechanical)		
Operating voltages		
Setting ranges		
No. of ON/OFF cycles		
Accuracy		
Rating of operating contacts		

6.0 LIGHTING AND SMALL POWER

Item	Main Distribution board	Essential Services
415 Volt Switchboards		
Manufacturer		
Type		
Busbar rating	Amps	
Breaking capacity	MVA	
Type and manufacture of fuses		
Type and manufacture of changeover contactor		
Rating of contactor hold-in coild	VA	
Pick-up voltage of contractor coil	V	
Drop-off voltage of contactor coil	V	
Range of adjustment in drop-off time	Secs	

7.0 BATTERIES, CHARGERS AND D.C. SWITCHBOARDS

DESCRIPTION

Batteries

Manufacturer	
Type	
Electrolyte	
Voltage	V
Capacity at 10 hour rate	A.H.
Number of cells	
Voltage per cell	V
Normal charging rate	A
Ampere hour efficiency at 10 hour rate	%
Ampere hour efficiency at 1 hour rate	
Dimensions of cells	mm
Dimensions of battery complete	mm
Weight of cell complete with electrolyte	KG
Total weight of battery complete	KG
Internal resistance per cell when full charged	Ohms
Battery voltage at end of the duty cycle specified	V

Charger

Manufacturer	
Type	
A.C. Input to charger	KVA
D.C. Output to charger	KW
Type of D.C. voltage control	
Range of D.C. Voltage control	V
Regulation	%
Overall dimensions	mm
Total weight	KG

Boost charge contactors:

a) Manufacturer	
b) Maximum current rating	A
c) Coil rating	W
d) Method of inter-locking	

Alarm relays:

a) Manufacturer	
b) Type and reference	
c) Power consumption:	W
i) Quiescent	W
ii) Operated	

Number and rating distribution circuits

Overall dimensions	mm
Total weight	KG

D.C. Switchboards

Manufacturer	
Type of construction	
Busbars:	
a) Maximum current rating	A
b) Dimensions	mm

8.0 NEUTRAL EARTHING EQUIPMENT

ITEM

Neutral Isolators

Manufacturer	
Type	
Number of breaks per pole	
Type of contacts	
Material of contact surface	
Normal rated current	A
Maximum short time current (3 seconds)	RMS KA
Air gap between poles of one phase	mm
Type of operating mechanism	
Total weight of single phase isolator complete	KG
Design voltage	KV
Minimum dry flashover	KV
Minimum wet flashover	KV
1 minute dry test	KV
Overall dimensions	mm

Resistors

Type (liquid or metal grid)	
Current rating (109 Secs)	Amps
Reistance at 30 Deg. C	Ohms
Electrolyte quantity (where applicable)	Litres
Dimensions:	
Height overall	m
Diameter	m
Plate thickness	mm
Bushings and electrode supports:	
Nominal voltage	KV
Minimum dry flashover externally	KV
Minimum wet flashover internally (in air above electrolyte)	KV
1 Min. dry test	KV

Neutral Current Transformers

Design voltage	KV
Minimum dry flashover	KV
Minimum wet flashover	KV
1 Min. dry test	KV
Overall dimensions	mm

9.0 FIRE FIGHTING EQUIPMENT

Dry Powder Wall Mounting Extinguisher

Manufacturer	
Dimensions	m
Weight	Kg
Type of dry powder	
Test pressure	Kg/cm2
Working pressure	Kg/cm2

50 KG Dry Powder Mobile Extinguisher

Manufacturer	
Dimensions	
Weight	Kg
Length of hose	m
Type of dry powder	
Test pressure	Kg/cm2
Working pressure	Kg/cm2

Water Sprinklers

10.0 33KV – XLPE CABLES

Sl No.	Description	
1	Make	
2	Standard to which cable conforms	
3	Voltage between phases of 3 phase circuit	KV
4	Number of cores	
5	Conductor (Cross Sectional Area Material Design Overall dimensions)	mm
6	Conductor Screen (Material Nominal thickness)	mm
7	Insulation (Material Min. radial thickness)	mm
8	Core Screen (Material) Nominal thicknessmm	
9	Metallic Layer or Sheath (Material No. of strips – Size of strips – Nominal thickness – Outer diameter)	mm
10	Armour (Type of wire – No. of wires – Dia of wire)	mm

11	Outer Covering		
	(Material Min. thickness – Anti termite deterrent)		mm
12	Completed		
	(Overall diameter – Weight per metre – Max. drum length)		m
13	Maximum Dielectric Stress		
	At the conductor screen (assumed smooth)		MV/m
14	Maximum Conductor Temperature		
	(Laid direct in ground		Deg. C
	(Drawn into ducts		Deg. C
	(Erected in air		Deg. C
15	Minimum Radius of Bend		
	Round which cable can be laid		
	(Laid direct		m
	(In ducts		m
	(In air		m
16	Nominal internal diameter of pipes or ducts through which cable may be pulled		mm
17	Maximum D.C. Resistance		
	Of conductor per metre of cable at 20 Deg. C		Ohm
18	Maximum A.C. Resistance		
	Of conductor per metre of cable at max. conductor temperature		Ohm
19	Insulation Resistance per KM of cable per case at 20 Deg.		
	(Meg. Ohm) at max. rated temperature (Meg. Ohm)		
20	Equivalent Star Reactance per metre of 3 phase circuit at 50Hz		Ohm
21	Maximum Electrostatic Capacitance per metre of cable		pF
22	Permissible Overload in sence conditions as stated under item 24		
23	Maximum Charging Current per conductor per metre of cable at		
	nominal voltage		mA
24	Current Carrying Capacity (see Ref. 26)		
	Laid in the ground	: One circuit A	
		: Two circuit A	
	Drawn into single	: One circuit A	
	Way ducts	: Two circuit A	
	In air	: One circuit A	

S. No. Description

25	CONDUCTOR SHORT CIRCUIT CURRENT		
	carrying capacity for one second, cable loaded as above before short circuit and final		
	conductor temperature 250 Deg. C		KA
26	METALLIC LAYER OR SHEATH LOSS of cable per metre of 3 phase circuit at		
	normal voltage, normal frequency and operating oil pressure at circuit rating as		
	stated in Ref : 20		W
27	METALLIC LAYER OR SHEATH EARTH FAULT CURRENT		
	carrying capacity for one second, cable fully loaded prior to earth fault and final		
	screen temperature of		Deg. C
28	CABLE DRUMS	(Diamter	m
		(Width	m
		(Weight loaded	Kg

29	Conditions upon which current carrying capacities are based Axial spacing between phase cables	mm
	Axial spacing between circuits	mm
	Soil thermal resistivity	Deg. C-m
	Ground temperature	Deg. C
	Air temperature	Deg. C
	Burial depth	m
	Type of earth bonding	
30	Earth continuity conductor cross section	mm2
31	Maximum standing voltage on sheath screen under fault conditio (V)	

11.0 AUXILIARY LV POWER CABLES

Ref.	Description	Unit	Types
1	Voltage	Volts	
2	Class of cable		
3	No. of cores		
4	Conductor c.s.a.	mm2	
5	Insulation Material Thickness	mm	
6	Armour	Thickness	mm
7	Armour No. of wires		
	Dia. of wires		
8	Other covering material Thickness	mm	
9	Completed cable overall dia. Weight per metre	Kg	
10	Maximum D.C. resistance of conductor at 20 Deg. C.	Ohms	

12.0 Auxiliary Control Cables

Ref.	Description	Unit	Types
1	Voltage	Volts	
2	Class of cable		
3	Number of cores		
4	Conductor (Cross section area	mm2	
5	Insulation (Material Thickness	mm	
6	Armour Bedding (Thickness	mm	
7	Armour (No. of wires		
	(Diameter of wires	mm	
8	Outer covering (Material Thickness	mm	
9	Completed Cable (Overall diamter		
	(Weight per metre	Kg	
	(Maximum drum length		
10	Maximum D.C. resistance of conductor per km of cable at 20 Deg. C	Ohm	

13.0 Description

HIGH FREQUENCY LINE COUPLING EQUIPMENT

Line Traps

Manufacturer	
Type of numbers	
Nominal current rating	Amps
Coil inductance	
Weight of line trap	Kg
Temperature rise at normal rating	⁎C
Thermal short circuit rating	
2 seconds	KA
3 seconds	KA
Dynamic short circuit rating	KA
Temperature rise at short circuit rating	⁎C
Working tension of strain mounted units	Kgm
Bandwidth blocked	kHZ
Attenuation in blocking band	db
Minimum impedance in working bandwidth	Ohms
Non compatiability with IEC Recommendations 353	Yes/No
If yes, enter in Schedule M	
Departures from specification	

HF COUPLING UNITS

Manufacturer	
Type of number	
Available bandwidth	kHz
Tuning range	kHz
Composite loss over tuning range	db
Line side impedance range	
Phase/Earth coupling	Ohms
Phase/Phase coupling	Ohms
Equipment side impedance	Ohms
Drain coil current carrying capacity	
Continuous	Amps
For 1 second	Amps
Isolation transformer voltage	
For 1 minute	
Main arrestor voltage	KV
Secondary arrestor voltage	volts
Earth switch interlock with door	Yes/No
Non compatibility with IEC Recommendation 481Yes/No	
If Yes, enter in Schedule A Departures from specification	

COUPLING CAPACITORS

Manufacturer	
Type of number	
Mounting	Kg
Weight	Kg
Rated capacitance	pF
Coupling capacitor insulation	

Test		
AC test		KV
Impulse withstand voltage		KV
Suitability for line trap		
Mounting		Yes/No
Creepage distance		

HIGH FREQUENCY CABLE

Manufacturer		
Type of number		
Coaxial or Quad		
Surge impedance		Ohms
Voltage withstand		
Between conductors		KV
Between cores and armouring		KV
Attenuation per kilometre		
At 50 kHz		db
At 500 kHz		db

CARRIER HIGH FREQUENCY UNITS

Manufacturer		
Type number		
Working temperature range		✳C to ✳C
Working voltage		
Normal D.C.	V	✘or –
Normal D.C.		✘ or –
Supply frequency	Hz	✘ or –
Power consumption of fully equipped terminal		Watts
Side bands (4 kHz)		
Type		
Transmit/Receive spacing		kHz
Transmit/Transmit spacing		kHz
Speech bandwidth		Hz
VFT channel working availability		Hz
Automatic gain control		Hz
Telephone signalling		Hz
Channel synchronising		Yes/No
Virtual carrier frequency stability		
Carrier frequency variations with temperature (state range) Hz		oC to oC
I.F. modulation frequency		kHz
Terminal power at output to coupling equipment		Watts
Carrier terminal output impedance		Ohms
Transmit return loss		db
Maximum transmitting level for parasitic signals		
At 300 Hz outside the limits of the H.F. channel		
At more than 12 Hz outside the limits of the H.F. channel		
Receiving level range at H.F. input		
Maximum		dbm
Minimum		dbm

Output power (PEP) before hybrid	Watts
At coaxial cable	db
Variation of speech level with respect to received H.F. level	
Speech channel characteristics without companders	
Nominal overall frequency response, 4 Wire to 3 wire relative to 800 Hz	
300 Hz	dBm0
1000 Hz	dBm0
1600 Hz	dBm0
2000 Hz	dBm0
2400 Hz	dBm0
Overall 800 Hz transmission loss	
4 wire to 4 wire	db
2 wire to 2 wire	db
4 wire/2 wire switching availability	Yes/No
Nominal levels	
4 wire transmit	dBr
4 wire receive	dBr
2 wire transmit	dBr
2 wire receive	dBr
VFT channel characteristics	
Nominal levels	
4 wire transmit	dBr
4 wire receive	dBr
Frequency difference between VFT input and VFT output betweena pair of terminals	Hz
Weighted telephone noise measured at the speec output of a pair of terminals without companders	dBmOp
Pulse distortion of the signalling channel at a speed of 10 pulses per second	
Non compatibility with IEC recommendation 495	Yes/No
If yes, enter in Schedule M Departure from specification	

TELE PROTECTION EQUIPMENT – 'DIRECT' TRIPPING

Manufacturer	
Type	
Working voltage	V ✗ or –
Power consumption	Watts
a) Quiescent	
b) Tripping	
VFT channel allocations	Hz
VFT channel oscillator accuracy	✗ or – Hz
VFT channel bandwidth required	Hz
Detail coding of signals	
Channel signalling speed from receipt of initiation to output control closure	m Sec
Duration of output pulse	m Sec
Dependent of duration of input pulse	Yes/No
Alarm facilities	
Transmitter fail	Yes/No
Receiver level low	Yes/No
Receiver fail	Yes/No

TELE SIGNALLING EQUIPMENT FOR TELE CONTROL SYSTEM

Bandwidth per channel	
Speed of channel	
Centre frequencies	Hz
VF channel frequency accuracy ✘ or – Hz	
Minimum signal/Noise ratio	db
Modem power suppoly	V
Input impedance	Ohms
Output impedance	Ohms
Temperature range	oC to oC
CCITT recommendation compatability	

TELEPHONE EQUIPMENT

Manufacturer and Type Nos.	
Working voltage Normal	V ✘ or –
Types and lengths of signalling impulses for	
Selecting	
Seizing of a carrier channel	
Releasing of a carrier channel	
Selective releasing of break in communications	
Private exchanges	
Number of HF lines	
Number of extensions	
Number of simultaneous conversations	
a) Trunk lines to extensions	
b) Extension to extension	
c) Extension to extension	
d) Transit calls	
Current consumption when all common equipment is in use	Amps

BATTERIES, CHARGERS AND D.C. SWITCHBOARDS ETC.

Batteries	
Manufacturer	
Type	
Voltage	Volts
Electrolyte	
Capacities at 10 hour rate	A.H.
Number of cells	
Voltage per cells	Volts
Normal float charge rate	Amps
Maximum hour efficiency at 10 hour rate	%
Ampere hour efficiency at 1 hour rate	%
Size of cell	hxwxd
Weights of cell complete with electrolyte	Kg
Internal resistance of batteries when charged	Ohms

Chargers

Manufacturer
Type rectifiers
Nominal input voltage
D.C. output of receifiers
Type of D.C. voltage control
Range of float D.C. voltage control
  Hand control — Volts
  Automatic control — Volts
Range of boost D.C. voltage control
  Hand control — Volts
  Automatic control — Volts
Rectifier transformer input rating — KVA
D.C. switchboard
    Type of switches
    Type of fuses
Distribution circuits (numbers and ratings) — Amps

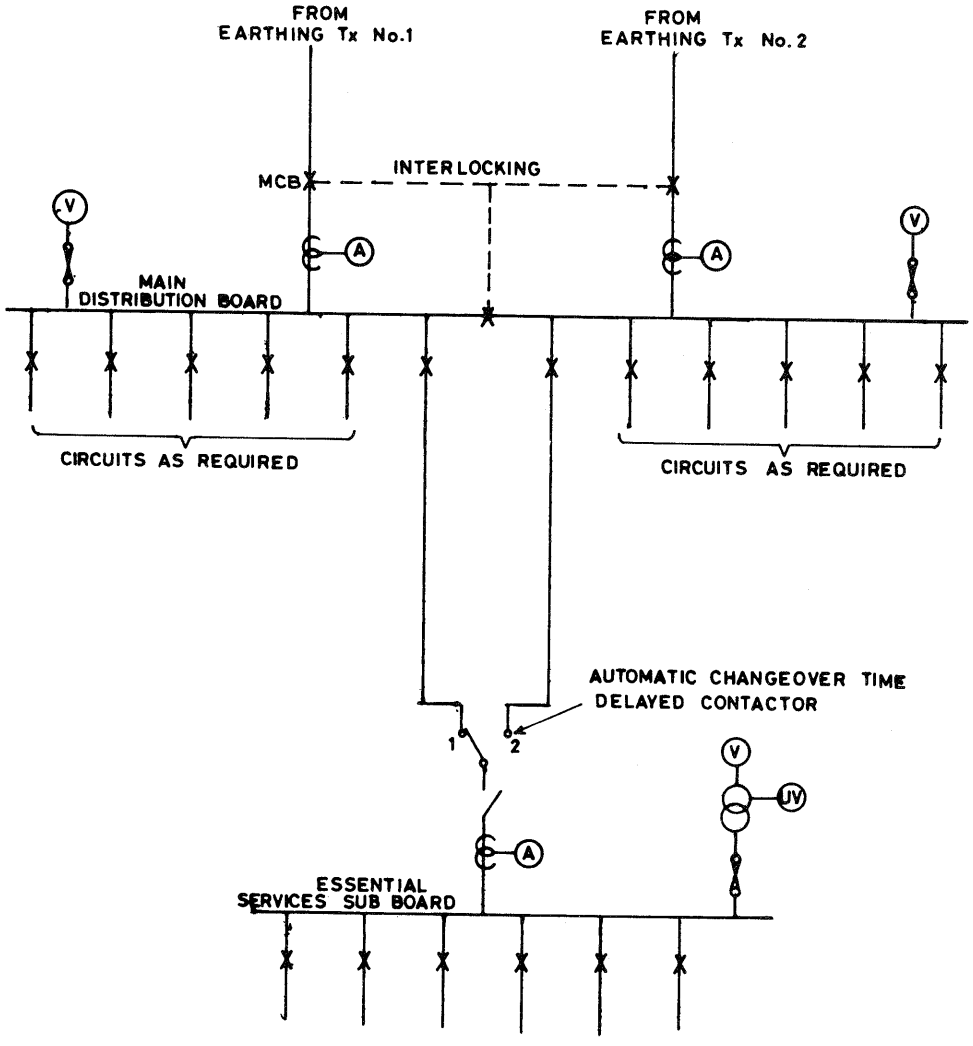
DETAILED SCHEDULE OF EQUIPMENT

Item No.	Item
1	Telephone exchange (PAX) capacity
	a) Number of extensions
	b) Number of trunk lines
	c) Number of connecting links
2	Power line carrier equipment
	a) Maximum output power, per carrier terminal to line
	b) Sideband configuration erect/inverted
	c) VF frequencies proposed for tele protection
3	Power supplies
	a) Battery type
	b) Total battery capacity at 10 hour rate
	c) Maximum simultaneous demand on battery
	d) Charger type
	e) Charger rating
	f) D.C. distribution board
	i) Mounting in charger
	ii) External to charger
	iii) Number and rating of fused outlets (Positive leg of outlet to include link)
	g) Number of cells
4	Dimensions of Apparatus cubicles length x depth x height metres

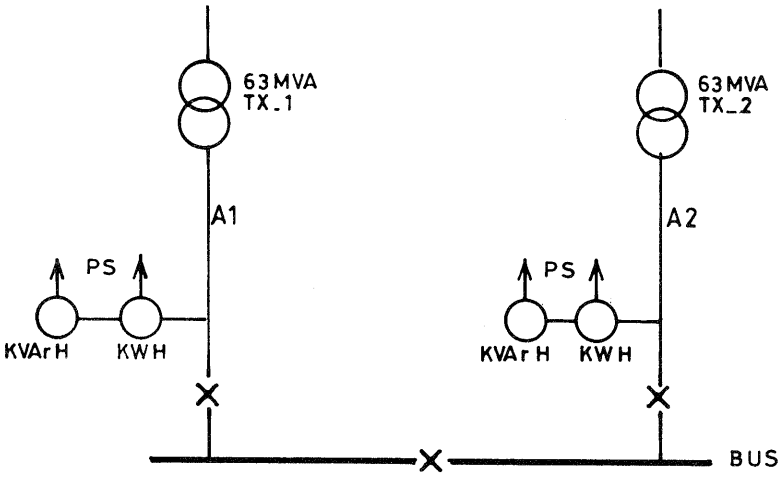
a) Telephone exchange
b) Power line carrier equipment
c) Battery charger
d) Teleprotection channels
e) Isolation transformers

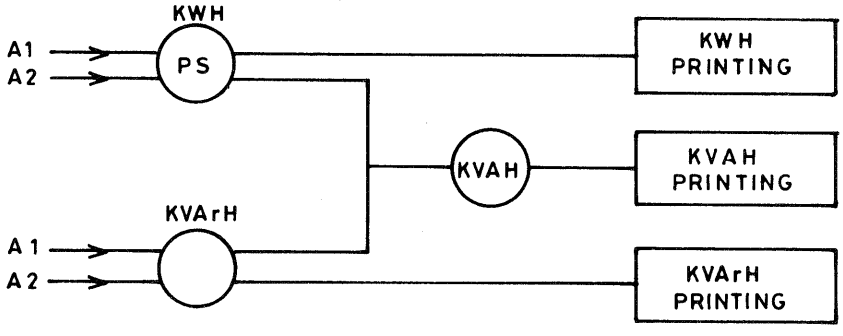
132KV 3 POLE DISCONNECTOR AND EARTHING SWITCH

S. No.	Description	Particulars
1	Manufacturer	
2	Disconnector type	
3	Type of number	
4	Isolator/Earthing switch type Type No.	
5	Isolator/Earthing switch drive	
6	Rated voltage	KV
7	Rated frequency	Hz
8	Rated current	A
9	Short time switch stand current (isec) (isolator KA rms)	
10	Ditto – but for earth switch	KA rms
11	Peak withstand current (isolator)	KA peak
12	Peak withstand current (earth switch only)	KA peak
13	Making current (peak, earth switch only)	KA peak
14	Lightning impulse voltage (1.2/50 us) withstand of disconnector	
	– line to earth	KV peak
	– across open isolator	KV peak
15	One min. power frequency withstand	
	– line to earth (50 Hz)	KV rms
	– across open insulator (50 Hz)	
16	Insulator creepage distance	mm
17	No. of spane auxiliary contacts	
18	Magnetising current breaking capacity	A
19	Charging current breaking capacity	A
20	Total weight	KG
21	Air gap between poles are phase	mm



MINISTRY OF ELECTRICITY&WATER DIRECTORATE GENERAL OF ELECTRICITY PLANNING DEPARTMENT		
SINGLE LINE DIAGRAM OF A.C. AUXILIARIES SUPPLIES		
DRAWN BY	CHECKED	APPROVED
FRANCIS		
SCALE N.T.S.	DATE - 22 . 07 . 91.	
DRG No. 132KV / 63MVA / 6		

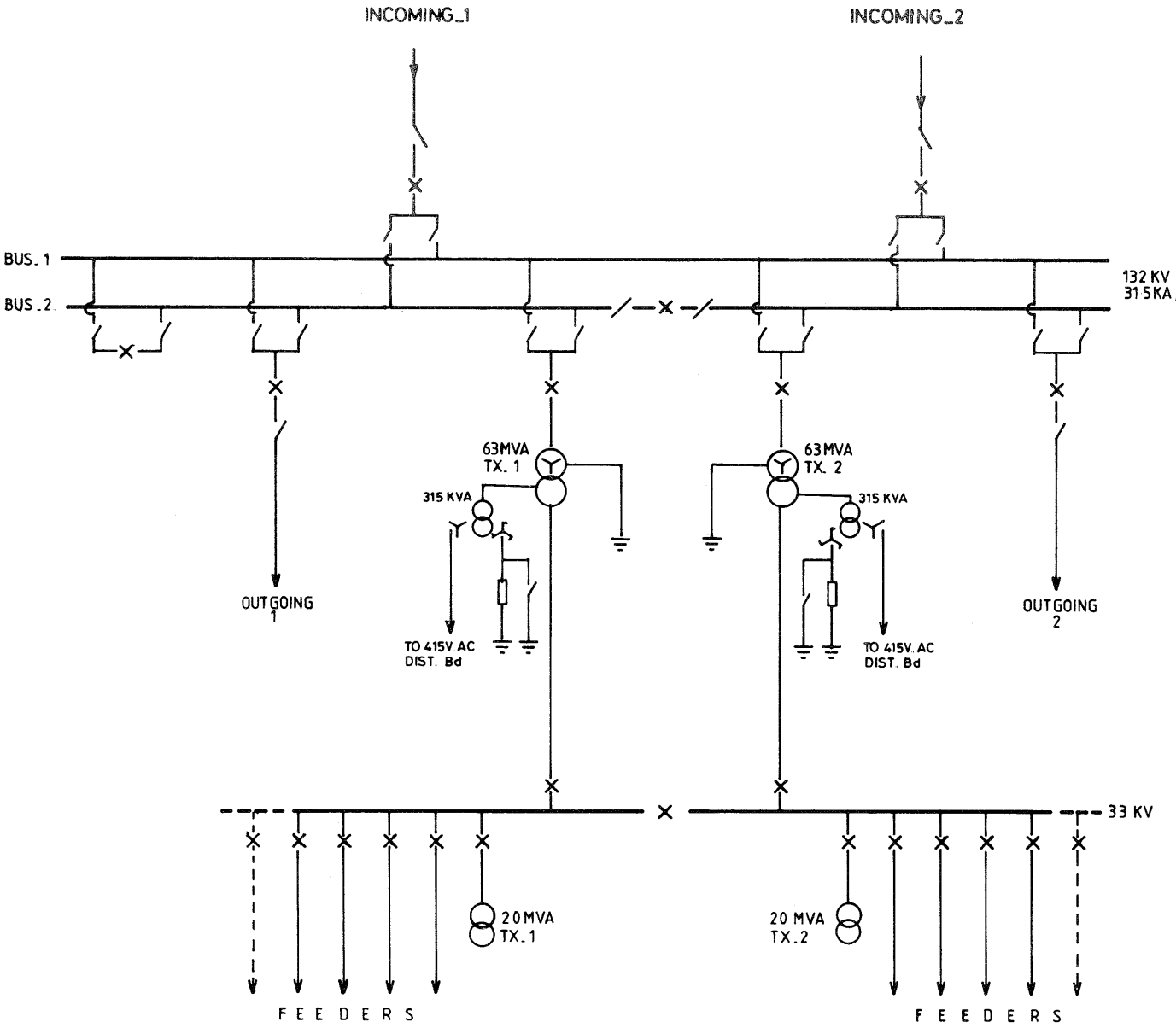




SULTANATE OF OMAN
MINISTRY OF ELECTRICITY AND WATER

132/33KV SUBSTATION (TYPICAL)
SINGLE LINE DIAGRAM OF 63 MVA
TRANSFORMER METERING

DRAWN	CHECKED	APPROVED
FRANCIS		
SCALE :	DATE : 25 - 08 - 1991	
DRAWING NO: MEW/132KV/63MVA/7.		



SULTANATE OF OMAN
MINISTRY OF ELECTRICITY AND WATER

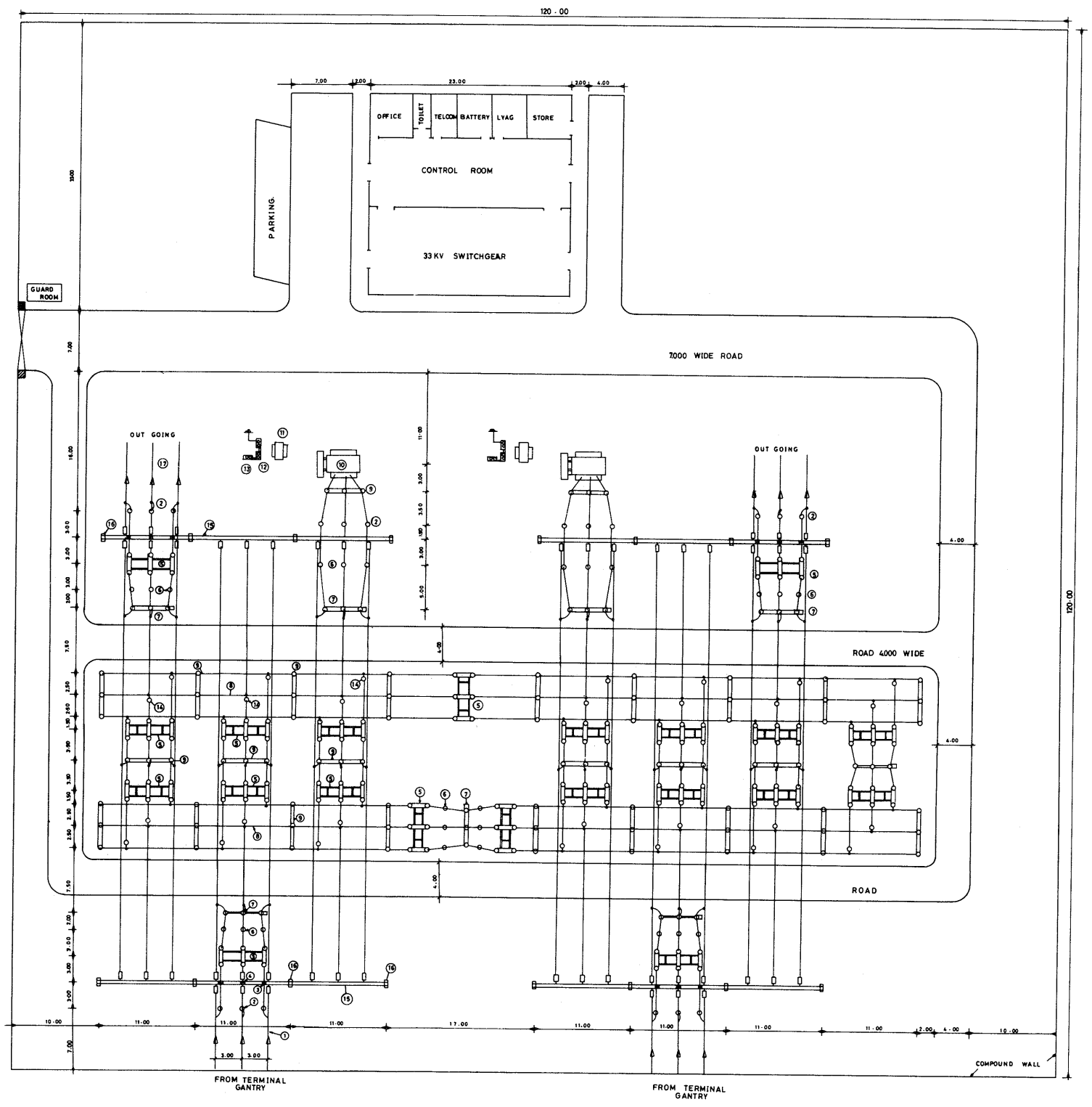
TITLE

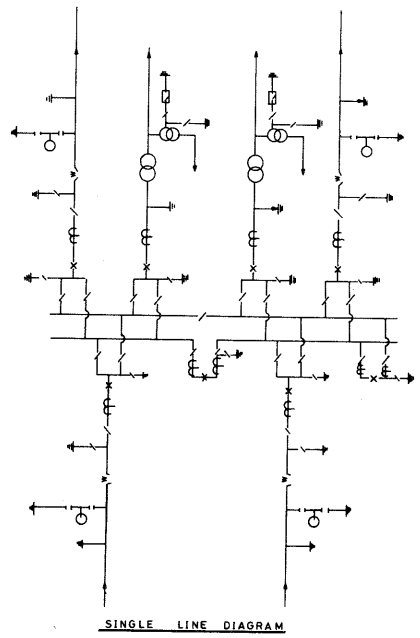
SINGLE LINE DIAGRAM FOR 132/33 KV
2 x 63 MVA TRANSFORMER SUBSTATION &
OPEN TYPE SWITCH GEAR
(TYPICAL)

DRAWN	CHECKED	APPROVED
FRANCIS		

DRAWING NO: MEW / 132/63MVA/2

SCALE: N.T.S. DATE: 28. 05. 1991.





SINGLE LINE DIAGRAM

LEGEND

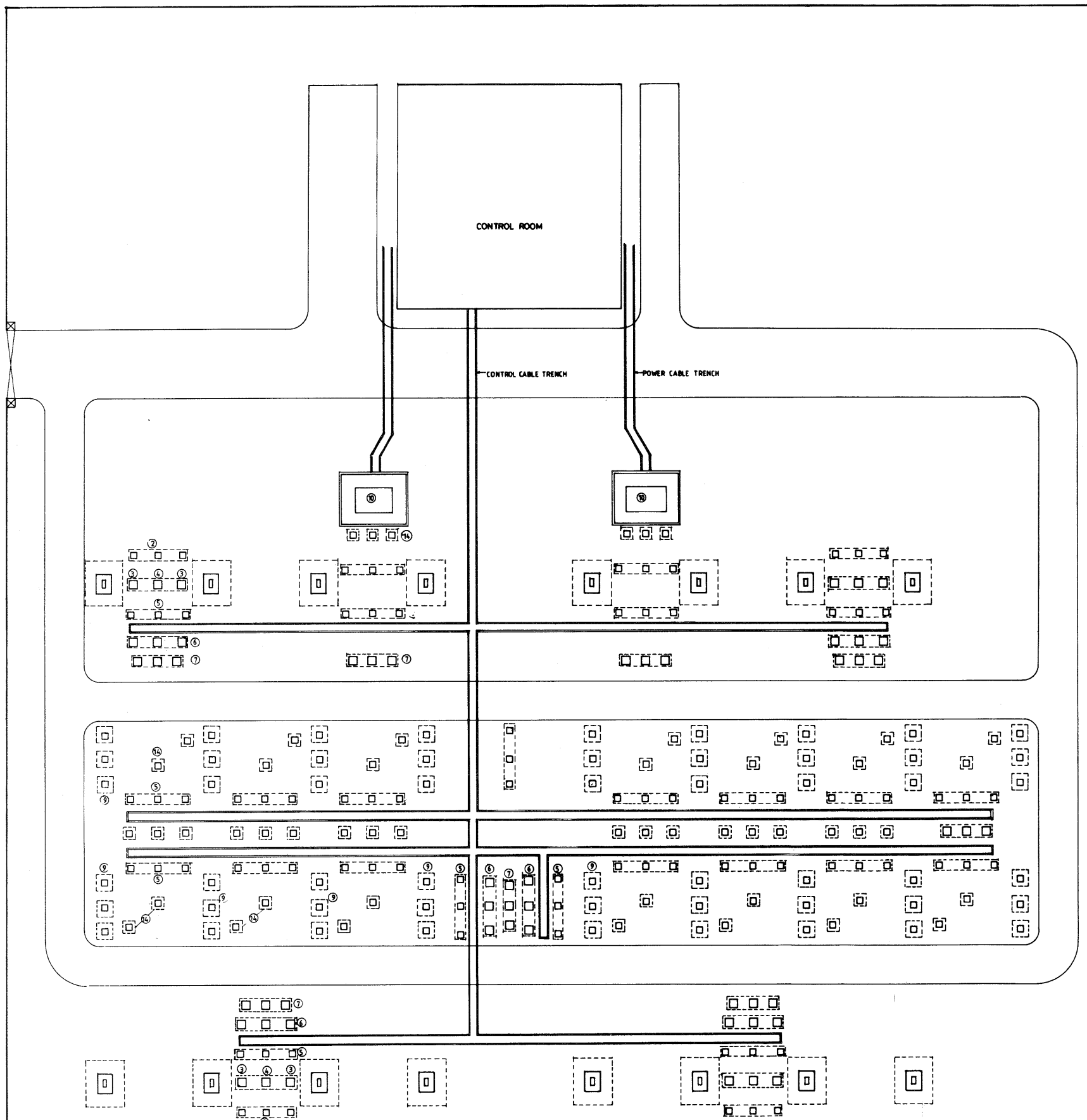
1 – 132 KV INCOMING FEEDER
2 – SURGE ARRESTOR
3 – C C V T
4 – LINE TRAP
5 – DISCONNECTOR WITH EARTHING SWTICH
6 – CURRENT TRANSFORMER
7 – CIRCUIT BREAKER
8 – BUSBAR
9 – BUSBAR SUPPORT
10 – 132 / 33 KV TRANSFORMER
11 – EARTHING TRANSFORMER
12 – DISCONNECTOR FOR NEUTRAL EARTHING RESISTOR
13 – NEUTRAL EARTHING RESISTOR
14 – POST TOP INSULATOR
15 – GIRDER
16 – TOWER
17 – OUT GOING FEEDER

SULTANATE OF OMAN
MINISTRY OF ELECTRICITY & WATER

GENERAL ARRANGEMENT OF 132 / 33 kv
63 M V A SUBSTATION (TYPICAL)

DRAWN	TRACED	CHECKED	APPROVED
FRANCIS	SALEM		

DRG No	DATE
132 KV / 63 M V A / 1	9 - 6 - 1991



LEGEND

2	132 KV SURGE ARRESTOR
3	VOLTICE TX
4	LINE TRAP
5	132 KV DISCONNECTOR
6	CURRENT TRANSFORMER
7	CIRCUIT BREAKER
9	BUS SUPPORT INSULATOR
10	132/33 KV 63 MVA TX
14	POST TOP INSULATOR

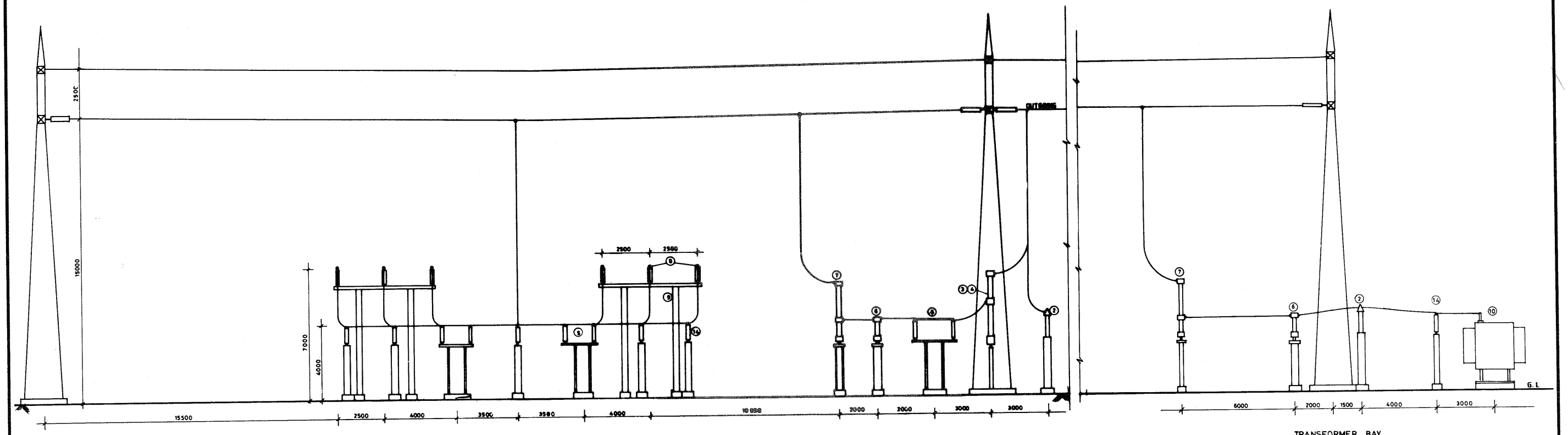
SULTANATE OF OMAN
MINISTRY OF ELECTRICITY & WATER

GENERAL ARRANGEMENT OF FOUNDATIONS AND CABLE TRENCH FOR 132/33KV SUBSTATION

DRAWN	CHECKED	APPROVED
FRANCIS		

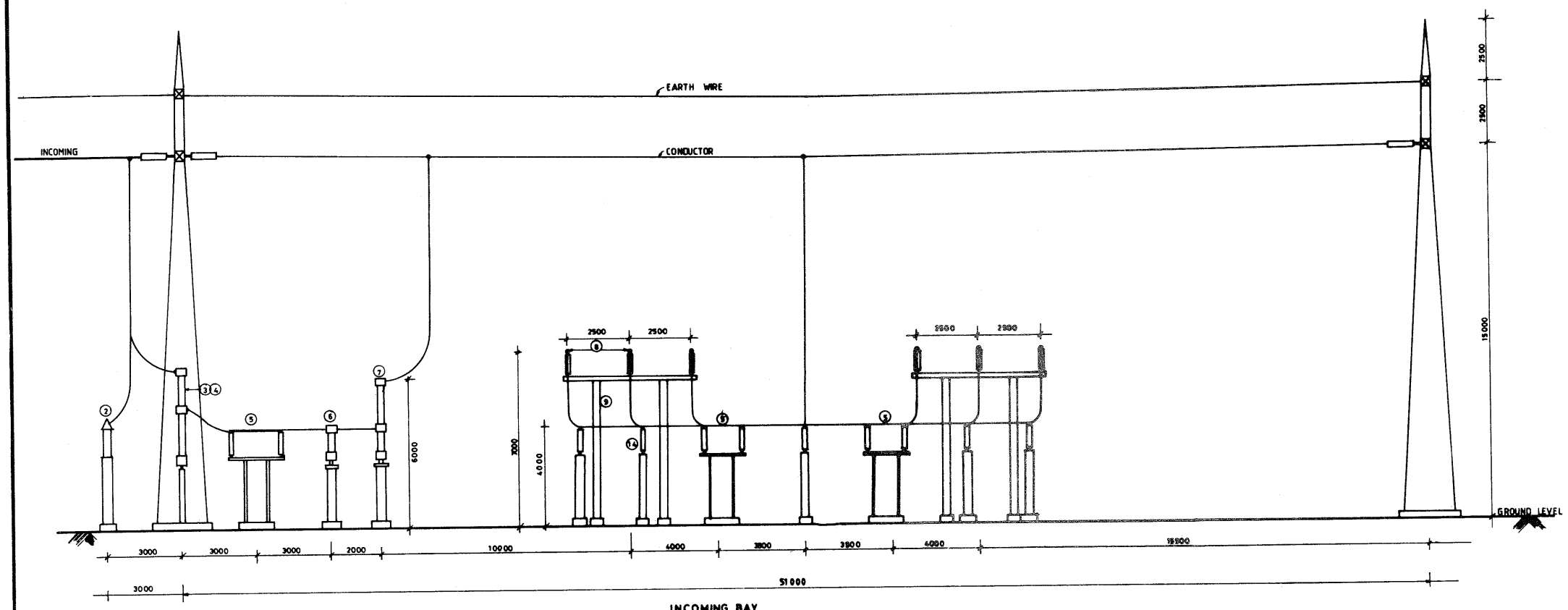
DRAWING NO. MEW/132KV/63 MVA/3

SCALE N.T.S | DATE 08.06.91



OUT GOING BAY

TRANSFORMER BAY



INCOMING BAY

LEGEND

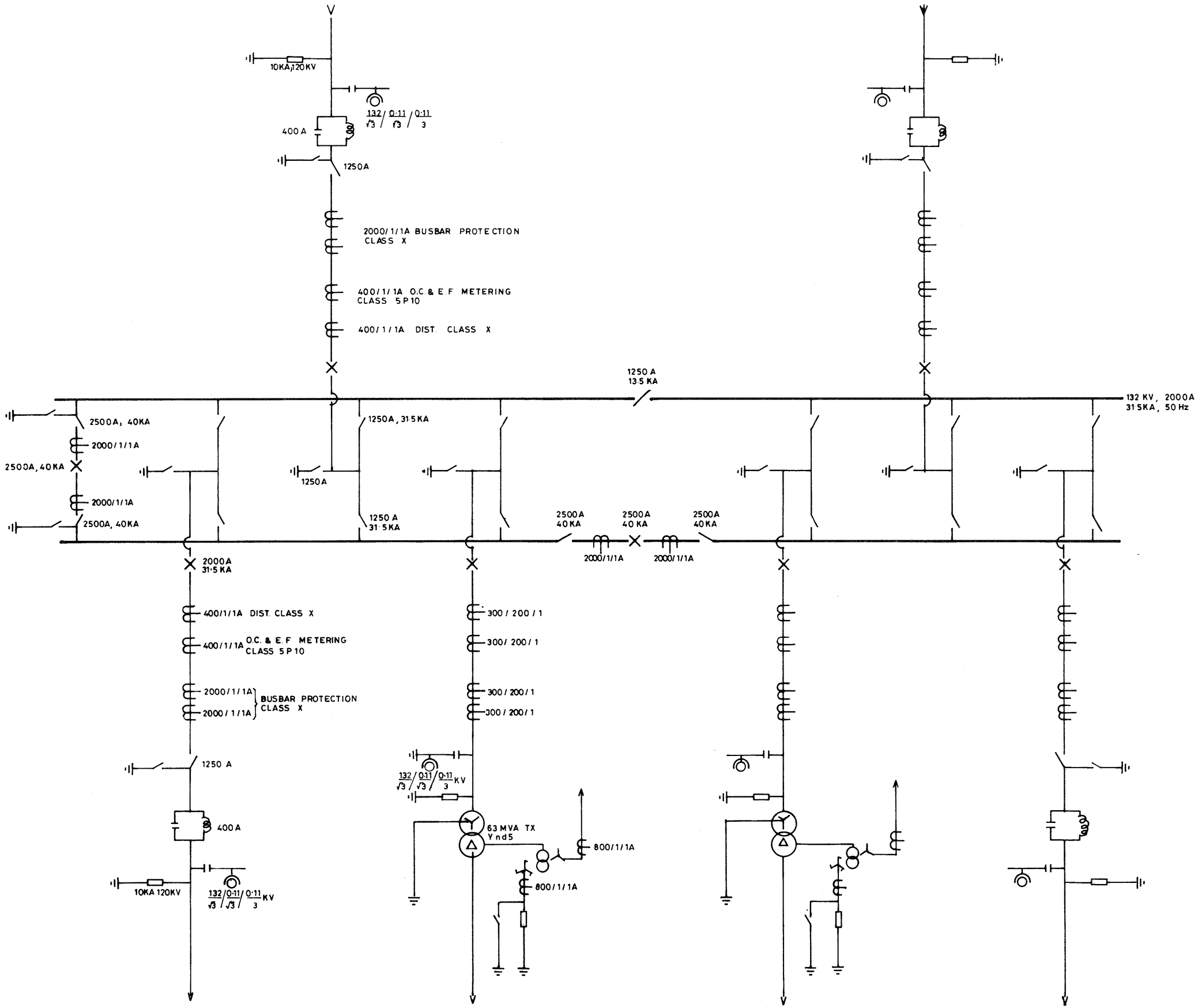
2	132 KV SURGE ARRESTOR
3	VOLTICE TX
4	LINE TRAP
5	132 KV DISCONNECTOR
6	132 KV CURRENT TRANSFORMER
7	132 KV CIRCUIT BREAKER
8	BUSBAR
9	BUSBAR SUPPORT
10	132 / 33 KV TRANSFORMER
14	POST TOP INSULATOR

SECTION CLEARANCE	: 3550 m m
EARTH CLEARANCE	: 1270 m m
PHASE CLEARANCE	: 1473 mm
GROUND CLEARANCE	: 2440 m m

SULTANATE OF OMAN
MINISTRY OF ELECTRICITY AND WATER

SECTIONAL ELEVATION OF
132/33KV SUBSTATION

DRAWN: FRANCIS	CHECKED:	APPROVED:
DRAWING NO: MEW/132KV/63MVA/4	SCALE: N.T.S.	DATE: 02 06 91



SULTANATE OF OMAN
MINISTRY OF ELECTRICITY & WATER

132 KV
SINGLE LINE DIAGRAM

DRAWN	CHECKED	APPROVED
FRANCIS		
DRAWING NO. MEW/132KV/63MVA/5		
SCALE : N.T.S.		DATE: 05 06 1991