PARTICULAR TECHNICAL SPECIFICATIONS FOR 33 kV SWITCHGEARS AND ASSOCIATED EQUIPMENT

1. Technical Description, Requirements and Data 6

1.1 Main Requirements for New Equipment 6

1.2 Technical Description and Data of Existing Equipment (not applicable) 6

1.3 Guarantees, Penalties and Rejection of Supply 7

2. Design, Materials and Workmanship 8

2.1. General 8

2.2. Applicable Standards 8

2.3. General Design Requirements 9

2.4. Interlocking 10

3. Detailed Requirements for the Equipment 11

3.1 33 kV Switchgear 11

3.1.1. General 11

3.1.2 Circuit Breakers 12

3.1.3 Disconnecting Facilities and Circuit Breaker Positions 14

3.1.4 Earthing Switches 14

3.1.5 Current Transformers 14

3.1.6 Voltage Transformers 15

3.1.7 Busbars 16

3.1.8 Cable Compartments and Cable Terminations 17

3.1.9 LV Compartments 17

3.1.10 Interlocking 18

3.1.11 Auxiliary Equipment and Accessories 18

3.1.12 Internal Wiring 19

3.1.13 Internal Wiring Terminals 19

3.1.14 Earthing 19

3.1.15 Identification Labels 20
3.1.16 Floor Frames 20
3.1.17 Adaptation of Existing 33 kV Switchgears (if required) 20
3.2 Control Equipment 20
3.2.1 General 20
3.2.2 Mimic Diagrams 21
3.2.3 Synchronising Facilities 21
3.2.4 Annunciators 21
1. General Arrangement 21
2. Alarm Indication Devices 21
3. Alarm Operation and Indication pattern 22
4. Alarm Initiation 22
5. Controls and Functions 22
6. Audible Alarms 22
7. Power Supply 22
8. Spare Capacity 23
9. Trip / Non-Trip Classification 23
10. Fascia and Alarm Transmission 23
11. Attended / Unattended Operation 23
12. Remote Status Indication 23
13. Alarm Equipment 23
3.2.5 Instruments and Meters 24
3.2.6 Supervisory Control, Telemetering and Indication 24
3.2.7 Marshalling Cabinets 25
3.2.8 Time Synchronization (Master Clock) not applicable 25
3.2.9 Control & Relay Panels General 26
3.2.10 Automatic Control for Capacitor Banks 26
3.3 Protection Equipment 27
3.3.1 Protection Philosophy 27
3.3.2 Discrimination 27

3.3.3 Construction and General Facilities 28
3.3.4 Indications 28
3.3.5 Contacts 28
3.3.6 Numeric Relays 29
3.3.7 Trip Circuit Supervision and Auxiliary Supply Monitoring 29
3.3.8 Commissioning and Routine Testing Facilities 29
3.3.9 Relay Settings 29
3.3.10 Environmental Requirements 30
3.3.11 Mechanical Environment 31
3.3.12 Electrical Environment 31
3.3.13 Insulation 31
3.3.14 Electromagnetic Compatibility 32
3.3.15 Thermal Requirements 32
3.3.16 Inverse Time Overcurrent and Earth Fault Relays 32
3.3.17 High Set Overcurrent, Instantaneous Overcurrent and Earth Fault Protection 33
3.3.18 Directional Overcurrent and Earth Fault Relays 33
3.3.19 Overcurrent and Earth Fault Definite Time Delay Relays 33
3.3.20 Circulating Current Protection 34
3.3.21 Tripping Relays 34
3.3.22 Circuit Breaker Failure Protection 34
3.3.23 Manual Synchronising Facilities 35
3.3.24 Check Synchronising Relay 35
3.3.25 33 kV Feeder (Cable/OHL) Protection 36
3.3.26 Transformer Protection 38
3.3.27 High Impedance Busbar protection 40
3.3.28 Low Impedance Busbar protection 41
3.3.29 Standby Earth Fault Protection 42

3.3.30 Under Frequency Load Shedding 42
3.3.32 Combined Protection Relays for 33 kV Circuits 44
3.4 Energy Meters 45
3.4.1 Main Characteristics 45
3.4.2 Functionality 46
3.4.3 Communications 47
3.4.4 Labelling 49
3.4.5 Security 49
3.4.6 Energy Meter Panels 49
3.4.7 Voltage Selection Scheme 50
3.4.8 Metering System Network 52
3.5 33 kV Capacitor Banks 53
3.5.1 General 53
3.5.2 Internal Fuses 54
3.5.3 Overvoltages and Overloads 54
3.5.4 Discharge and Earthing Devices 54
3.5.5 Duty under Fault Conditions 54
3.5.6 Rating and Property Plates 54
3.5.7 Racks for Capacitor Units 55
3.5.8 Series (Current Limiting) Reactors 55
3.5.9 Surge Arrester & Counter 56
3.5.10 Current Transformer for Unbalance Detection 57
3.5.11 Interlocking and Access 57
4. INSPECTION AND TESTS 58
4.1. General 58
4.2. Factory Tests 59
4.2.1. General 59

4.2.2. Type Tests Certificates 59

4.2.3. Routine Tests 60

5. Documentation 63

5.1. Documentation to be Submitted with the Tender 63

5.2. The Documentation to be Submitted after Contract Commencement Date 63

1. Technical Description, Requirements and Data

1.1 Main Requirements for New Equipment

The 33 kV switchgears with pertaining control and protection panels, which are subject of these Technical Specifications, shall be installed **in the new Aqaba 400/132/33KV (AAWDCP) substation and 33/11 kV BPS01 substation and feeding IPS & RO SS**.

33 kV switchgears shall be designed in accordance with the requirements of the Standard IEC 62271-200 and other relevant Standards if not otherwise required in this Specification.

In addition, 33 kV capacitor banks, which are subject of these Technical Specifications as well, shall be installed **in the new Aqaba 400/132/33KV (AAWDCP) substation and 33/11 kV BPS01 substation and feeding IPS & RO SS**.

33 kV capacitor banks shall be designed in accordance with the requirements of the Standard IEC 60871 and other relevant Standards if not otherwise required in this Specification.

33 kV switchgears and associated equipment shall be designed in such a manner to meet the requirements required in this Technical Specifications, Schedules of Technical Data Schedule D and Drawings at climate conditions at the Site defined within the General Technical Specifications.

The rated characteristics of 33 kV switchgears and associated equipment are given in Schedule A: Scope of Supply & Schedule D: Schedule of Technical Data.

In addition to the defined equipment delivery, the Contractor shall also be responsible for any necessary for proper functioning of complete substations. This shall include, but not limited to, detailed layout & cross section drawings of the 33 kV equipment's in substations showing equipment and systems which shall be procured in substation, 33KV equipment's single line diagrams, any required bus bar calculations, conductor calculations, calculation of cables, AC & DC load calculations and their drawings (single line diagrams, circuit & wiring diagrams, etc.), drawing for steel support structures for 33 kV outdoor/ indoor apparatus and their foundations, calculation and selection of LV AC & DC power cables and control, signalling, measuring and communication cables, cable lists, circuit & wiring diagrams for overall control, protection and metering schemes, as well as communication schemes as per NEPCO standards and solution adopted for the particular substation. The Design documentation that shall be provided under this Contract has been defined in the Particular Technical Specifications.

The Contractor shall be responsible for complete scheme (control & protection schemes, metering schemes, etc.) and proper functioning of the equipment procured within this tender/ contract.

The Tenderer/Contactor shall visit the Sites (for existing SS and extension projects) and make himself aware of the details of the existing system/facilities. The modification work at the associated substation shall be compatible with the existing system.

1.2 Technical Description and Data of Existing Equipment (not applicable)

Since that for extension projects (Substation 132/33kV) adaptation of existing 33 kV switchgears may be required, the characteristics of those existing 33 kV switchgears are given in the following Table.

33 kV Switchgear Characteristic	Substation 132/33 kV
Manufacturer	
Type	
Rated voltage	

Rated insulation level (LI/AC)	
Rated busbar current	
Rated short-time withstand current	
Rated peak withstand current	

Furthermore, in order to enable the Contractor to prepare relevant Detail Design, the Client shall make available to the Contractor the As-Built documentation that he possesses regarding the extension and replacement projects. However, if any drawing or other document shows to be unavailable or that it is lacking the necessary data, the Contractor is obliged to obtain the necessary information at the Site by performing the necessary surveying personally.

1.3 Guarantees, Penalties and Rejection of Supply

Contractor shall guarantee that 33 kV switchgears and associated equipment shall fully comply with characteristics given in the schedule A: scope of work and schedule D: Schedule of Technical Data.

In case that the supplied equipment does not comply with requirements stated in these Particular Technical Specifications, as well as those stated in the Schedule of Technical Data, the Client has a right to reject the Supply.

2. Design, Materials and Workmanship

2.1. General

The design, materials and workmanship shall be in compliance with the *General Technical Specifications* and particularly with these Particular Technical Specifications.

The 33 kV switchgears and associated equipment shall be designed and manufactured to fully correspond to the climatic and operating conditions specified in the *General Technical Specifications*.

2.2. Applicable Standards

Unless otherwise specified, the 33 kV switchgears and associated equipment shall be fully designed and manufactured in accordance with these Technical Specifications and the latest editions of the following IEC, BS, and IEEE Standards:

- IEC 60050, International Electro-technical Vocabulary (IEV),
- IEC 60417 DB, Graphical symbols for use on equipment,
- IEC 60617 DB, Graphical symbols for diagrams,
- IEC 60038, IEC standard voltages,
- IEC 60071, Insulation co–ordination,
- IEC 61936, Power installations exceeding 1 kV a.c.,
- IEC 60721, Classification of environmental conditions,
- IEC 60529, Degrees of protection provided by enclosures (IP Code),
- IEC 61000, Electromagnetic compatibility (EMC),
- IEC 60085, Electrical insulation,
- IEC 60068, Environmental testing,
- IEC 62271, High-voltage switchgear and control gear,
- IEEE Std C37.20.2, Standard for Metal - Clad Switchgear,
- IEC 61869, Instrument transformers,
- IEC 60060, High Voltage Test Techniques,
- IEC 61850, Standard for Substation Automation,
- IEC 60255, Measuring relays and protection equipment,
- IEC 60068, Environmental testing of electronic equipment,
- IEEE C37.2, Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations,
- IEEE C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus,
- IEEE C37.230-2020, IEEE Guide for Protective Relay Applications to Distribution Lines,
- IEEE C37.99-2012, IEEE Guide for the Protection of Shunt Capacitor Banks,
- IEC 60688, Electrical measuring transducers for converting A.C. and D.C. electrical quantities to analogue or digital signals,

- IEC 62052-11, Electricity metering equipment - General requirements, tests and test conditions, Part 11: Metering equipment,
- IEC 62053-22, Electricity metering equipment (a.c.) - Particular requirements, Part 22: Static meters for active energy (classes 0,2 S and 0,5 S),
- IEC 62053-23, Electricity metering equipment - Particular requirements, Part 23: Static meters for reactive energy (classes 2 and 3),
- EC 62053-31, Electricity metering equipment (a.c.) - Particular requirements, Part 31: Pulse output devices for electromechanical and electronic meters (two wires only),
- IEC 62053-52, Electricity metering equipment (a.c.) - Particular requirements, Part 52: Symbols,
- IEC 62056-21, Electricity metering - Data exchange for meter reading, tariff and load control, Part 21: Direct local data exchange,
- IEC 60359, Electrical and electronic measurement equipment - Expression of performance,
- IEC 60871, Shunt capacitors for a.c. power systems having a rated voltage above 1000 V,
- IEC 60076-6, Power transformers – Reactors,
- IEC 60099-4, Surge arresters – Metal-oxide surge arresters without gaps for a.c. systems
- IEC 60502, Power cables with extruded insulation and their accessories for rated voltages from 1 kV (*U*m = 1,2 kV) up to 30 kV (*U*m = 36 kV).

If the Tenderer offers design, equipment, workmanship or testing in compliance with any Standard, which deviates from the above-mentioned Standards, such deviations shall be submitted along with his Tender.

Application of any Standard other than the above mentioned, shall be the subject of the Client's approval.

2.3. General Design Requirements

The design and manufacture of the entire equipment shall be in accordance with the latest international standards in this field and it shall be envisaged for a long-term operation.

Particular attention shall be paid to preparation of adequate conceptual solution, easy access, simple operation and logical arrangement of individual parts.

Parts of the equipment having the same rated values and characteristics shall be identical and completely interchangeable.

Spare parts shall be fabricated to enable easy installation and accurate fitting, without the need for subsequent adjustments.

Easy and smooth maintenance of the 33 kV switchgears and associated equipment shall be ensured.

During continuous operation with rated characteristics, no part of the equipment shall be damaged due to overheating.

33 kV switchgears and associated equipment shall be designed in accordance with the values of short-circuit currents specified in the schedule D: Schedule of Technical Data. 33 kV switchgears and associated equipment shall be designed so that the influences of maximum short-circuit currents, which may occur due to any reason, do not cause any damage (electrical or mechanical) on the equipment.

The 33 kV switchgears and associated equipment shall be able to withstand, without any damage, the highest voltages and loads, which might occur in any conceivable operating condition.

All elements exposed to significant wear shall have removable wearing parts in order to enable easy and cost-effective repair or replacement.

2.4. Interlocking

For operation of the 33 kV circuit breakers, the following interlocks are required:

- The 33 kV circuit breakers shall be tripped when the associated power transformer 132 & 33 kV circuit breakers are tripped for any reason, including manual tripping,
- Any 33 kV circuit breaker shall be prevented from closing unless its circuit protection trip relay is reset and the associated power transformer 132 & 33 kV circuit breakers are closed,
- Interlocking between 33 kV SWGR earth switch and neutral resistance disconnector and 132 kV circuit breaker, all signals shall transfer to the SCADA system.
- Interlocking between the 33 kV circuit breakers and associated earthing switches shall be such that:
    - The earthing switch cannot be closed unless the associated circuit breaker is opened and disconnected,
    - The circuit breaker cannot be closed unless the associated earthing switch is opened.

Additional interlocking is required on the capacitor bank circuits as follows:

- Capacitor bank circuit breakers shall not be closed unless the necessary time delay has elapsed after last opening of the circuit breaker to allow the associated capacitor bank to discharge,
- Locking devices of capacitor bank fence gates (provided under this contract) and earthing switches shall have the following interlocks:
    - The fence gate cannot be opened unless the earthing switch of the associated capacitor bank is closed,
    - The earthing switch cannot be opened unless the associated fence gate is closed.

3. Detailed Requirements for the Equipment

3.1 33 kV Switchgear

3.1.1. General

The 33 kV switchgear shall consist of modular, metal-clad, air-insulated cubicles for indoor installation.

33 kV switchgears shall be installed in separate switchgear rooms within substation control buildings.

33 kV switchgear shall be designed in accordance with the requirements of the Standard IEC 62271-200 and other relevant Standards if not otherwise required in this Specification.

The 33 kV cubicles shall have minimum mechanical protection degree IP41 and the protection degree of internal partitions shall be at least IP2X in accordance with IEC 60529.

The 33 kV switchgears shall consist of the requested number of free-standing, self-supporting cubicles. The thickness of sheet steel shall not be less than 2 mm.

The width of the 33 kV cubicles shall be suitable to room and building.

Each cubicle shall contain the following four (4) compartments, which shall be mutual separated by metal partitions:

- Busbar compartment,
- Circuit breaker compartment,
- Cable compartment,
- Low voltage compartment.

Each cubicle shall be separated from another cubicle by means of metal panels, except the busbar part, which may be installed without partitions between cubicles.

In accordance with IEC 62271-200 standard, the cubicles shall be of the following classes:

- Loss of service continuity class: LSC 2B,
- Arc resistance class: IAC AFLR,
- Internal partition class: PM.

The circuit breaker compartment shall be located at the front of the cubicle.

The arrangement and positions of other compartments may be defined and implemented in accordance with the Manufacturer's usual practice, provided that easy access for maintenance and inspection is possible at any time.

The cubicles shall be equipped with capacitive voltage dividers necessary for indication of voltage presence in all three phases. The Voltage Presence Indicators (VPI) shall be mounted on the cubicle front.

Instruments, alarm and signalling elements and all control elements shall be installed in/on cubicles, at the height of 800÷1800 mm above the floor in order to enable easy readings and handling by the staff.

Access to the cubicles, for operation, maintenance and inspection, shall be enabled both from the front and rear side.

All compartments shall be equipped with appropriate hinged doors or detachable panels, sealed in an approved manner, in order to protect the personnel against accidental contact with live parts. For this purpose, the compartments with withdrawable (draw-out) type equipment shall be provided with mechanical interlocks on their

doors and shall have suitable, automatically operated metallic shutters to cover the access to live parts when the equipment is drawn-out from the compartments.

All doors shall be fitted with a sealing gasket on the rim, which shall firmly press against the housing when closed.

Where required for the safety of operators the switchboard shall be provided with lockable doors, screens and guards to prevent accidental contact to live parts, with means of locking.

Busbar shutters, circuit shutters and voltage transformer spout shutters shall be painted and labelled in an approved manner.

Durable phase colour-indications shall be provided in a prominent position.

The structure of the cubicles and equipment layout in the cubicles shall enable cable connection from the cubicle bottom. Cubicle bottom covers shall be sealed after cable installation.

All equipment installed inside the cubicles shall be fixed to supports. All outgoing current circuits from the cubicles shall be connected to easily accessible terminal strips.

All cubicles shall be delivered complete, together with instruments, all internal wiring, terminal strips, cable glands in accordance with the envisaged cables, etc.

The cubicles shall have adequate earthing connections.

The switchgear shall be suitable for extension at either end.

3.1.2 Circuit Breakers

The 33 kV Circuit Breakers (CBs) shall be fully withdrawable with roll on floor trolley (floor drawn full truck), suitable for indoor installation.

The 33 kV CBs for capacitor banks shall be withdrawable, SF6 type, specially designed for capacitor bank application. The Contractor shall, together with the Tender, submit the clear evidence (analysis, calculation, etc.) that the offered SF6 type circuit breaker is suitable for capacitor bank application. The SF6 gas pressure shall be monitored, and low pressure shall be alarmed.

All other 33 kV CBs (for cable feeder cubicles, transformer cubicles, bus section cubicles) shall be withdrawable, vacuum type.

Circuit breakers shall be designed in accordance with the requirements of the Standard IEC 62271-100 and other relevant Standards if not otherwise required in this Specification.

Circuit breakers of the same rating shall be fully-interchangeable.

Beside the rated short circuit breaking current, the circuit breakers shall be capable of making and breaking the excitation current, including inrush current of the transformer, and purely charging current without restricting and generating harmful over-voltage.

The 33 kV CBs operating mechanism shall be of 110 V DC trip free motor wound-spring charged type and all phases shall be operated simultaneously by a common shaft.

Operating mechanisms fitted with shunt-trip circuits (i.e., energise to trip) shall also be fitted with trip circuit supervision. This supervision shall not alarm when the CB is isolated.

It shall be possible to charge the operating springs with the circuit breaker in either open or closed positions. In normal operation, recharging of the operating springs shall commence immediately and automatically upon completion of the closing operation. Closure while a spring charging operation is in progress shall be prevented and release of the springs shall not be possible until they are fully charged.

The operating mechanism shall have a hand-charging facility and it shall be possible to discharge the operating springs at site from a charged condition without difficulty. Manual spring release shall also be provided. The charging spring motor shall be interlocked so that it cannot operate when manual charging is selected.

The state of charge of the operating springs shall be indicated by a mechanical device which shows "*Spring Charged*" when operation is permissible and "*Spring Free*" when operation is not possible. Also, a provision shall be made for remote indication of "*Spring Charge Fail*" conditions. Therefore, a spare spring-drive limit switch contacts and necessary time delay relays shall be provided.

Remote indication of circuit breaker in/out of service position shall be provided.

The circuit breaker compartment door shall be provided with a window so that when the circuit breaker is in service position and the door is closed the indications on the circuit breaker can be read from outside the cubicle.

All circuit breakers shall be fitted with operations counters.

33 kV circuit breaker shall be equipped with one (1) tripping coil and one (1) closing coil. The closing circuit shall be equipped with the anti-pumping device. The tripping coils shall be suitable for application of trip circuit supervision relays. A trip free operating mechanism is required so that circuit breaker will be free to open immediately during a closing operation if the tripping device operates. Means shall also be provided to prevent the mechanism from responding to a close signal when the trip coil is energised.

The circuit breaker shall be equipped with a facility for manual operation for maintenance purposes.

Circuit breaker operating mechanism shall have a sufficient number of normal open (NO) and normal close (NC) auxiliary contacts, with at least 20% of the spare contacts (but at least 2 of each type). Where any particular scheme requires special timing of auxiliary contacts, these shall be provided.

All circuit breaker control accessories shall be for 110 V DC. The tripping, closing and control accessories shall be capable of operating at control voltages between 85% and 110% of the rated control voltage value.

A visual, mechanical, circuit breaker position on/off indicator positively driven by the mechanism (cord drives excluded) shall be provided. It shall be operative and visible in each circuit breaker truck position.

The design of circuit breakers and circuit breaker withdrawable trolley (truck) shall enable three (3) positions, as follows:

- "*Service*" position – with the truck fully engaged inside the compartment and primary and secondary contacts connected,
- "*Test*" position – with the truck partially drawn out, primary contacts disconnected, secondary contacts connected but no live contacts exposed (shutters closed),
- "*Withdrawn*" position – with the truck fully withdrawn, primary and secondary contacts disconnected and compartment fully and safely accessible.

All positions such as CB in Service/Test/Withdrawn shall be mechanically indicated.

The action of isolation and withdrawal shall be separate and independent. Means shall be provided to lock and padlock the circuit breaker in the service or test position.

Earthing of the circuit breaker shall remain effective until it is fully withdrawn from the cubicle.

Controls shall be blocked during the isolation.

When the circuit breaker truck is in its defined test position the contact parts of the busbars and feeder must be covered by automatic metallic shutters.

The busbar and feeder shutters shall be capable of being individually operated and padlocked.

The shutters shall open automatically by a positive drive initiated by the movement of the circuit breaker. The closing operation shall also be automatic either by a positive drive or by two independent means, each capable of operating one shutter alone.

For testing purposes an integral device shall be provided for opening the shutters individually and retaining the shutters in open position. This device shall be easily released manually to allow the shutters to close. The insertion of the circuit breaker truck shall override the manual shutter operating device so that the automatic shutter operation is restored.

3.1.3 Disconnecting Facilities and Circuit Breaker Positions

Integral facilities shall be provided for the positioning of the circuit breaker in the "*Service*", "*Test*" and "*Withdrawn*" positions. Provision shall be made for rigidly locating the circuit breaker in each position. All necessary interlocking and other features required for safe operation shall be provided. Attempted movement shall not cause a circuit breaker to trip.

When the mass of the circuit breaker and its truck together with all other equipment mounted thereon is greater than 100 kg and isolation of the circuit breaker is achieved by horizontal movement, e.g. truck mounted circuit breaker with horizontally disposed bushings, a mechanical means shall be provided for driving the circuit breaker through the isolating contact engagement and in addition a distance sufficient to obtain the withstand dielectric requirements between the associated contacts.

The mechanical drive shall be interlocked to allow its use only with the circuit breaker in the open position.

Plug connections, including those for auxiliary wiring, shall be of the self-aligning type.

The fixed portion of plug connections shall be readily accessible for maintenance.

3.1.4 Earthing Switches

Each circuit shall be provided with an earthing switch installed within the cubicle and located between the circuit breaker and cable box.

Earthing switch shall have fault making capacity and short-time rating equal to that of the circuit breaker.

The earthing switches shall be envisaged for indoor installation and they shall be designed in accordance with the requirements of the Standard IEC 62271-100 and other relevant Standards if not otherwise required in this Specification.

Illuminated inspection windows shall be provided for inspection of the earthing switch blade position. Maintenance of the illumination equipment shall not require access to the MV chamber.

The direction of opening and closing the earthing switch shall be clearly marked to advise the operating personnel of the direction of operation for closing and opening. Earthing switch shall be operated by means of a separate operating handle which shall be inserted into the front of the switchgear through a fully interlocked and lockable access opening.

A sufficient number of normal open (NO) and normal close (NC) auxiliary contacts shall be envisaged for earthing switches, with at least one (1) normally open (NO) and one (1) normally closed (NC) spare contact.

Earthing switches shall be directly connected to the main earthing bar in the cubicle, with adequately dimensioned conductors.

3.1.5 Current Transformers

The Current Transformers (CTs) shall be single-phase, cast in epoxy resin, envisaged for indoor installation.

Current transformers shall be designed in accordance with the requirements of the Standards IEC 61869-1&2 and other relevant Standards if not otherwise required in this Specification.

The active part of the current transformer shall be cast in epoxy resin, which shall ensure proper electrical insulation characteristics and mechanical protection of transformers. The epoxy resin insulation shall be done by means of a single moulding operation in order to obtain a uniform and compact insulating block, free of blow holes or other internal irregularities which might affect its characteristics and performance.

The rated transformation ratios, rated outputs and other rated characteristics of current transformers are given in schedule A: Scope of Supply & schedule D: Schedule of Technical Data.

The rated extended primary current shall be 120% of the rated primary current.

Current transformers shall have the following accuracies:

- Class 0.2S for tariff metering,
- Class 5P20 for overcurrent & earth fault protection,
- Class X (PX according to IEC 61869-2) for pilot wire, differential & high impedance busbar protection,
- Class P or X for low impedance busbar protection upon the NEPCO approval.

The Contractor is obliged to determine the rated outputs and other characteristics of the current transformers protective and measuring cores for the normal and transient operating conditions, as well as to coordinate them with the protection and measuring devices. The Contractor shall submit all necessary calculations and analysis to the Client for approval.

Design calculations for current transformers for use with all the provided relays shall be submitted to the Client for approval within three (3) months of contract award. CT design shall be based on a maximum fault level equivalent to the 33 kV switchgear rating

If the CT with five (5) or four (4) cores (where specified) cannot be provided by Contractor/Manufacturer, the solution with two (2) separate CTs with total of five (5) or four (4) cores, all within the cubicle, shall be acceptable.

The secondary terminal block shall be incorporated into the resin moulding and protected by a detachable cover in a position easily and safely accessible for inspection and maintenance. Design of the terminal block shall prevent any possibility of accidental opening of the secondary circuits. All secondary leads shall be wired to the shorting type terminals.

Each current transformer secondary winding circuit shall be earthed at only one point through the removable link, which shall enable easy and safe access for testing purposes. Wherever possible the connection to earth shall be at S3 terminals.

Access to the current transformer secondary circuits shall be enabled and shall be safe without the need to switch-off the voltage on the primary side.

Secondary connections of the current transformers shall be carried out as screw terminals, and the type of threaded connections shall not be accepted.

3.1.6 Voltage Transformers

The Voltage Transformers (VTs) shall be single-phase, single-pole insulated, cast in epoxy resin, envisaged for indoor installation.

Voltage transformers shall be designed in accordance with the requirements of the Standards IEC 61869-1&3 and other relevant Standards if not otherwise required in this Specification.

The active transformer part shall be cast in epoxy resin, which shall ensure proper electrical insulation characteristics and mechanical protection of transformers. The epoxy resin insulation shall be done by means of a

single moulding operation in order to obtain a uniform and compact insulating block, free of blow holes or other internal irregularities which might affect its characteristics and performance.

The rated transformation ratios, rated outputs and other rated characteristics of voltage transformers are given in schedule A: Scope of Supply & schedule D: Schedule of Technical Data.

Voltage transformers shall have the following accuracies:

- Class 0.2 for tariff metering,
- Class 1 for metering and instruments,
- Class 3P for protection.

The Contractor is obliged to determine the rated outputs and other characteristics of the voltage transformers protective and measuring secondary windings for the normal and transient operating conditions, as well as to coordinate them with the protection and measuring devices. The Contractor shall submit all necessary calculations and analysis to the Client for approval.

The voltage transformers shall have a voltage factor of 1.2 continuous / 1.9 for 30 seconds.

Voltage transformers shall not be loaded to more than 75% of their rated output.

Voltage transformers in transformer and bus section/metering cubicles shall be withdrawable with HV fuses for protection of VT primary windings.

Voltage transformers in feeder cubicles shall be fixed without fuses at VT primary side.

Voltage transformers shall be equipped with miniature circuit breakers (MCBs) on the secondary side.

Isolation of the primary fuses shall be carried out by withdrawing the entire voltage transformer assembly, e.g., by using guide rails. A shutter shall be provided on the fixed HV part of the panel to cover the HV conductors when the voltage transformer is withdrawn. The operation and locking facilities for the shutters shall be similar to those of the circuit breaker.

MCBs on the secondary side of the VTs shall be equipped with two (2) sets of normally open and two (2) sets of normally closed auxiliary switches which shall be wired to local terminal blocks and an alarm shall be given to indicate that the MCB has been tripped.

The voltage transformers secondary windings shall be earthed at only one point through a removable link, which shall enable easy and safe access for testing purposes.

The secondary terminal block shall be incorporated into the resin moulding and protected by a detachable cover in a position easily and safely accessible for inspection and maintenance. Secondary connections shall be wired on the terminal strip of the cubicle.

It shall not be possible to parallel the secondary windings of any two voltage transformers.

3.1.7 Busbars

The single busbar system of insulated type shall be accommodated in the appropriate compartment running along the switchgear in order to provide the proper connection of all equipment between the busbars and outgoing cable terminals, in accordance with the corresponding single line diagram.

Each busbar phase conductor and tee-off branches to other compartments shall be made of high purity electrolytic copper, having silver-faced connecting ends, and connected together in an appropriate manner, in order to prevent loosening under any circumstances, and shall be supported by an appropriate number of post insulators.

The shape, composition, and cross section of the conductors shall permit the safe carrying of the continuous busbar current and of the short-time current without exceeding the following maximum temperature rises:

- Continuous current: 65 K,
- Short-circuit current for 3 s: 180 K.

The busbars shall also be dimensioned, arranged and fastened in such a way to withstand safely the peak dynamic short-circuit current, without transmitting excessive stresses to the insulators and other parts of the cubicle.

Expansion joints of an appropriate type shall be provided in adequate positions along the busbars in order to take up the thermal expansions without damaging the supporting insulators and other equipment (the joint and clamps shall be copper or silver-faced).

The busbar system shall be completed with the necessary copper connections to the equipment compartments. The connections to the circuit breakers shall be made through suitably shaped plug-in type princer contacts. These are to ensure an adequate permanent pressure on the contacts when inserted to safely withstand the short-circuit currents without excessive heating or sticking of the contacts and to facilitate the relative movement and self-centering of the contacts when the equipment is withdrawn. These contacts shall be enclosed in appropriate porcelain or resin bushing insulators and shall normally be covered by the automatic shutters of the equipment compartments.

The busbars and connections shall be supported at appropriate intervals by post insulators with a type suitable to withstand safely the stresses transmitted by the busbars and connections and permanently to maintain their electrical insulating characteristics under the most severe circumstances.

3.1.8 Cable Compartments and Cable Terminations

Entry of 33 kV cables shall be from the cubicle bottom side.

The cable compartments shall be accessible from the rear of the cubicle through hinged or removable panels and suitably dimensioned to permit the installation of all indoor type cable terminals.

Low-voltage power and control, signalling & measuring cables shall be separated and protected from the medium-voltage equipment inside the cubicle.

Low-voltage terminal strip, terminals and cables shall be clearly marked in accordance with the wiring diagrams provided by the Contractor together with the switchgear. A place for fixing of LV power and control, signalling & measuring cable terminations shall be envisaged.

The cable compartments shall be provided with glands, and provisions shall be made to prevent the access of water, moisture, sand, dust, vermin or any other injurious foreign matter.

Inside the compartments, suitable crutches shall be provided to support and fasten the cable sealing ends and for the earthing connection of the cable sheaths.

All sheaths and all unused cable cores shall be connected to the adequate earthing bar.

The electrical connections between cable terminals and busbars shall be made by means of detachable links of an approved type, enabling the dismantling of each individual cable without disturbing the others.

3.1.9 LV Compartments

The low-voltage (LV) compartment shall, depending on substation and 33 kV cubicle type/purpose, contain the equipment and devices specified in schedule A: *Scope of Supply*.

3.1.10 Interlocking

Switchgear interlocking shall be according to IEC 62271-200. Mandatory interlockings shall be mechanical. Electrical or electro-mechanical interlocking shall only be used where specifically permitted by these specifications.

The Client shall have the right to add any interlocking which he considers necessary for safe operation during the engineering/design stage.

All interlockings provided throughout the switchgear shall be of the preventive rather than corrective type.

Interlockings shall prevent any unsafe operation of the switchgear and shall ensure that the operator follows safe and logical sequences of switching device operations.

The following interlockings shall be mandatory:

- The withdrawal of a circuit breaker shall be impossible unless it is in the "*open*" position,
- The operation of a circuit breaker shall be impossible unless it is in the "*service*" or "*test*" position,
- It shall be impossible to close the circuit breaker in the "*service*" position unless it is connected to the auxiliary circuit, or unless it is designed to open automatically without the use of an auxiliary circuit,
- Withdrawal of the auxiliary circuit control plug shall not be possible with the circuit breaker in the "*service*" position,
- Switching operations shall be performed with the circuit breaker compartment door closed,
- The door of the compartment shall be prevented from being opened unless the cubicle is isolated,
- It shall not be possible to operate the earthing switch when the circuit breaker is in the normal "*service*" position,
- It shall not be possible to close or open any earthing switch unless the relevant equipment is isolated from possible sources of supply,
- Earthing switch cannot be closed unless the circuit breaker is in "*test*" or "*withdrawn*" position,
- When the earthing switch is closed (the line is earthed) circuit breaker cannot be placed in "*service*" position,
- Any interlocking capable of being avoided without the use of special tools for a particular safe purpose shall be provided with a padlocking facility.

In addition, the 33 kV circuit breaker for each main transformer shall be interlocked with its associated 132 kV circuit breaker such that:

- The 33 kV circuit breaker cannot be closed unless the 132 kV circuit breaker is already closed,
- The 33 kV circuit breaker shall be tripped if the 132 kV circuit breaker is opened.

3.1.11 Auxiliary Equipment and Accessories

Each cubicle shall be equipped with at least the following equipment and accessories:

- Interior lighting of the low-voltage compartment, which shall automatically switch-on when the appurtenant door opens,
- Anti-condensation heaters within the individual compartments (except busbar compartment). The heater shall be switched on automatically when the circuit is de-energised and shall be hydrostatically controlled over the humidity range 50÷100%,

- Single-phase socket-outlet,
- Earthing bar, which shall be mounted along the compartment, to all de-energised metal parts. The earthing bar shall be made of pure copper with adequate dimensions.

3.1.12 Internal Wiring

Internal wiring shall comply with the following:

- Fire performance: Flame retardant to IEC 60332,
- Insulating material: PVC moisture resistant,
- Insulation grade: 600 V,
- Conductors: Tinned stranded copper,
- Minimum core size:
  - for control wiring: 2.5 mm^2,
  - for AC and DC power wiring. 2.5 mm^2.

Multi-strand conductor ends shall be fitted with a crimped terminal device with an insulating straight shank.

Wiring across door hinges shall be protected against mechanical damage, e.g. by the use of flexible conduits.

Wiring between compartments shall be carried within a duct and shall be accessible without the need for de-energising any circuits. Sufficient space shall be left in ducts and trunking for at least 10% of the wires to be installed after delivery to the Site.

Separate supplies for the circuit breakers shall be run for indication, tripping and closing circuits.

All wiring shall be traceable from the Contractors/Manufacturers drawings.

3.1.13 Internal Wiring Terminals

Screw clamp (or stud) type terminals shall be provided. Pressure plates shall be incorporated such that neither screws nor nuts bear directly on a wire.

For internal wiring, not more than two wires shall be attached under any terminal screw or post.

Terminals for different AC voltages shall be separated from each other by a barrier and completely segregated from DC circuits.

Wiring terminal blocks shall be arranged and positioned to afford easy access for carrying out external cabling, maintenance, inspection and testing. For current and voltage transformer secondary circuits, terminals with facilities for measuring, secondary injection testing, isolating or short-circuiting, as necessary shall be provided.

Terminals shall be made of polyamide material or better.

A minimum of 20% spares of each type of terminals shall be provided on each terminal block or strip in each compartment or cubicle.

All terminals shall be traceable from the Contractors/Manufacturers drawings.

3.1.14 Earthing

A main copper earthing bar shall be provided extending the whole length of the switchgear.

In order to ensure adequate electrical continuity between all metal non-current carrying parts of the switchgear and the main earthing bar, particular care shall be taken to the following:

- Housing of withdrawable circuit breaker shall be adequately earthed in the "*Service*" and "*Test*" position by appropriate earthing connections,
- External or exposed parts, e.g. bolts, screening, terminals, insulators, bus ducting and cable boxes shall be bonded to the steel frame of the switchgear,
- All earthing connections of current and voltage transformer shall be made directly from the terminal blocks to the main earthing bar,
- All metallic instrument cases, switches, etc., shall be properly earthed to the switchgear steel frame,
- All hinged doors upon which instruments, switches etc., are mounted shall be bonded to the fixed portion of the switchgear by a suitably sized flexible braid. Safety doors and barriers shall be similarly bonded.

3.1.15 Identification Labels

Each cubicle shall be provided with labels, mounted on the front and rear of a non-removable part of the panel clearly indicating the panel number and function, i.e. circuit or load name. The labels shall be secured with screws and shall have white characters on a black background and shall have characters at least 20 mm high.

Labels indicating the function of internal devices, and terminal block numbers and wire groups shall be provided. All internal devices such as relays, fuses, miniature circuit breakers, switches shall be identified by the same numbers or letters as used in the schematic and wiring diagrams and a name shall be used to avoid ambiguity where necessary. The labels shall be secured with screws and shall be of black, non-deteriorating materials, e.g. Resopal or Trafolite, and shall be inscribed or engraved with white characters in the English language.

3.1.16 Floor Frames

If the 33 kV switchgears shall be erected and bolted onto a purpose-built floor frames, the Contractor shall provide the floor frames, which shall enable the cubicles to be easily and simply aligned during installation at the Site.

The frame shall include all jacking bolts, shims, packing pieces, nuts, bolts, washers etc., that are necessary during the erection at site. The top surface of the frame will be flush with the switchgear room floor.

3.1.17 Adaptation of Existing 33 kV Switchgears (if required)

If the extension of existing 33 kV switchgear (adding cubicles/panels) requires the adaptation of the existing 33 kV switchgear (information given in Particular Technical Specifications), the Contractor shall provide all necessary equipment and materials for that adaptation.

The preferred type of adaptation of the existing 33 kV switchgear is through adaptation cubicle. Other solutions of adaptation of existing 33 kV switchgears, e.g., 33 kV busbar bridge/bus duct shall be subject of Client's approval.

The adaptation of existing 33 kV switchgear shall be presented in Contractors Design, which shall be a subject of Client's approval.

3.2 Control Equipment

3.2.1 General

At all substation the Control facilities shall comply with these Technical Specifications, schedule A: *Scope of Supply* and schedule D: *Schedules of Technical Data* and the facilities required for supervisory operation from the National Control Centre shall be terminated in a Main Distribution Cubicle. The RTU required for the SCADA connection to NCC is described in a separate section.

Control panels and control desk supplied and installed in the substation control/relay room under this Contract shall provide all necessary facilities for the safe and effective control of the substation and equipment being supplied under this and other Contracts. A control selector switch labelled "*Remote/Supervisory*", lockable in both positions shall be provided for each bay (each Control & Protection panel) as detailed in the schedule A: Scope of Supply. A selector switch "*Substation Attended/Substation Unattended*" on Alarm and Control Station Desk shall in the "*Unattended*" position disconnect all indications, visual and audible alarms in the substation.

At all substations, the control philosophy for new equipment shall match the existing schemes.

3.2.2 Mimic Diagrams

Control panels shall be provided with a mimic diagram, which shall be aligned and clearly showing the main power connections in single line schematic form at a convenient height so as to permit operation and visual inspection of discrepancy control switches and indicator switches shall be incorporated. The single line to be formed from a plastic strip, minimum dimensions 2×10 mm (thickness×width), which must be permanently fixed to the panels by screws or an approved adhesive. The strip colour should be as follows:

System voltage kV	Colour acc. to BS 381C
132	Black
33	Green No 221
0.4	Light orange No 557

For replacement and extension projects, the mimic diagrams shall comply and shall be aligned with the existing mimic diagrams on existing control & protection panels.

Discrepancy control switches and semaphore indicators shall be incorporated into the mimic diagrams. Discrepancy control switches shall be provided for all circuit breaker, disconnector and fault making earthing switches. Semaphore indicators shall be provided for non-fault making earthing switches and for indication of the position of certain circuit breakers and disconnectors as required by the schedule A: *Scope of Supply*. Discrepancy lamps shall be arranged to light when the position of the main power device is at variance with the indicator and shall extinguish when the main power device and indicator are in agreement. An audible warning (control room buzzer) shall also sound during the discrepancy condition.

Discrepancy switches shall be push-to-rotate type (two actions). Each discrepancy switch shall be marked with corresponding operation number.

3.2.3 Synchronising Facilities

Synchronising facilities are required on all circuit breakers as specified in the appropriate sections of this Specification.

3.2.4 Annunciators

1. General Arrangement

- A multi-way alarm annunciator shall be provided on each control panel for indication of all alarms associated with circuits controlled from that panel.
- Each alarm shall be displayed on an individual annunciator window.

2. Alarm Indication Devices

- All alarm indications shall use heavy-duty LED lamps.

- Incandescent lamps are not permitted.
- LED lamps shall be suitable for continuous duty, high visibility, and long service life (Confirmation & garneted for 150000 operating hours at least).

3. Alarm Operation and Indication pattern

Each alarm shall operate with the following three conditions:

1. Alarm Operated
    - LED flashes on the annunciator window.
    - Audible alarm operates:
        - "Trip" alarms: shall initiate a common bell.
        - "Non-Trip" alarms: shall initiate a common buzzer.
2. Alarm Accepted
    - Audible alarm silenced.
    - LED remains continuously illuminated.
3. Alarm Cancelled (reset)
    - Audible alarm silenced.
    - LED extinguished.
    - Alarm ready for subsequent operation.
    - Cancellation shall only be possible after the initiating condition has reset.

4. Alarm Initiation

- Alarm annunciator ways shall accept initiation by:
    - Normally open or normally closed contacts.
    - Fleeting or persistent signals.
- Initiation of a new alarm after acceptance of a previous alarm shall:
    - Cause the new alarm LED to flash.
    - Re-activate the audible alarm.

5. Controls and Functions

- All annunciators shall have common (in control desk):
    - Accept
    - Reset (Cancel)
    - Lamp Test
- Acceptance of one alarm shall not inhibit operation of any other alarm in the group.
- Alarms may be accepted but shall not be cancelled (reset) until the initiating condition clears.
- A lamp test shall illuminate all LED lamps and the common bell and buzzer.

6. Audible Alarms

- "Trip" alarms shall operate a common bell.
- "Non-Trip" alarms shall operate a common buzzer.
- Buzzers for alarm annunciation shall be distinct from discrepancy switch buzzers.
- A common audible silence function shall be provided, without affecting visual indication.
- Audible alarms shall re-sound upon initiation of any new alarm.
- No audible alarm shall be used on the alarm fascia itself (if applicable), only the common bell or buzzer is required to be activated while substation is attended. Otherwise, A common audible silence function shall be provided, without affecting visual indication

7. Power Supply

- Alarm system supply shall be dual (operate on 110 V DC and 230 VAC).
- A dedicated DC supply failure alarm relay shall be provided.
- The DC failure alarm annunciator shall:
  - Be separate from the main annunciator.
  - Be supplied from an independent power source, not from the 110 V DC battery system.

8. Spare Capacity

- A minimum of 20% spare alarm windows, with not less than two (2) spare windows, shall be provided on each annunciator.

9. Trip / Non-Trip Classification

- Each alarm shall be selectable as:
  - Trip (Urgent), or
  - Non-Trip (Non-Urgent).
- Classification shall determine operation of common bell or buzzer.
- Selection shall be performed at the alarm relay level.

10. Fascia and Alarm Transmission

- A common alarm fascia shall be provided for each circuit and mounted on the associated control panel.
- Fascia shall be multi-window type with self-seal-in relays and flashing LED indication.
- The fascia shall not provide repeat relay contacts for transmission to NCC.
- Alarm transmission to NCC shall be derived directly from alarm relays, not from fascia contacts.
- Fascia indication shall be for local visual indication only.

11. Attended / Unattended Operation

- A selector switch shall be provided on the station control desk for:
  - Substation Attended
  - Substation Unattended
- In Unattended mode:
  - All audible alarms shall be inhibited.
  - Alarm relays shall continue to operate and transmit alarms to NCC.
- Upon change to Attended mode:
  - All alarms that operated while unattended shall:
    - Initiate dedicated LED and common audible alarms (common bell or buzzer).
- Alarms shall only be accepted or cancelled (reset) locally or from substation control desk in Attended mode.

12. Remote Status Indication

- The attended/unattended selector switch shall provide:
  - One potential-free contact closing in Attended position.
  - One potential-free contact closing in Unattended position.
- These contacts shall be wired to the remote control and supervisory system.

13. Alarm Equipment

- The alarm scheme shall include:
  - Alarm relays
  - Auxiliary relays

- Flasher relays
- Audible devices (bells and buzzers)

- At least 20% spare alarm contacts shall be provided

3.2.5 Instruments and Meters

Indicating instruments and integrating meters shall be provided as specified in the appropriate sections of this Specification.

Where specified instruments shall be provided with internal recording facilities.

3.2.6 Supervisory Control, Telemetering and Indication

At all the substations, the equipment supplied shall allow control from, and provide indication and measurands to the National Control Centre.

3.2.6.1 Control

Equipment shall be provided to allow control of the following from the National Control Centre, when the remote/supervisory switch is in the supervisory position:

- Close/trip of all circuit breakers,
- Acceptance of all active alarms incoming from a substation,
- Resetting of all electrically reset trip relays.

The duration of the control pulse from the supervisory equipment is two seconds and any equipment required to obtain satisfactory operation with the two second pulse shall be provided.

3.2.6.2 Indications

On/off position indication shall be provided to the National Control Centre for the following items:

- Circuit breaker,
- Earthing switch,
- Automatic/Manual selection,
- Supervisory control in service,
- Local/remote control in service.

These indications shall be transmitted to the NCC via RTU irrespective of the position of the panel mounted "Local/Remote/Supervisory" selector switch or the "Local/Remote" selector switch.

3.2.6.3 Alarms

All alarms annunciated in the station control room shall be repeated to the National Control Centre (NCC).

3.2.6.4 Measurements and Transducers

Programmable Transducers with multi outputs shall have the following characteristics:

- Type of connection: 3-phase, 4-wire,
- Programmable inputs primary and secondary for CT, VT and programmable analogue outputs between full range (-20 mA DC to +20 mA DC),

- Multi outputs 4 analogue outputs (MW, MVAr, V, A), each output to be programmed for any quantity,
- Response time: less than or equal 300 ms,
- Aux supply: 125 V DC,
- Accuracy class: 0.5 for (MW, MVAr, V, A) or better,
- The continuous overload rating of the transducer shall not be less than 1.3 times rated voltage and 2 times the rated current,
- Programming kit (software + communication cables) via RS485 port,
- Additional USB programming port is preferable.

The peak-to-peak noise current delivered by transducers shall not exceed 2 per cent of the maximum signal current. The response time shall be approximately 300 milliseconds or less to reach 90 per cent of the full rated output.

For new substations, the temperature and humidity equipment and transducer will be installed on the roof of the substation building and their outputs wired to supervisory interface panel.

Signals shall be provided for the National Control Centre (NCC) as follows:

- Feeder MW, MVAr, kV and A,
- Transformer A (on HV side),
- Transformer MW, MVAr, kV and A (on LV side),
- Busbar (phase to phase) voltage,
- Busbar frequency,
- Substation temperature,
- Substation humidity.

3.2.7 Marshalling Cabinets

Separate floor mounted marshalling cabinets shall be provided under this contract to form the interface between the substation equipment and the RTU equipment.

For all 132/33 kV new substations and substation extensions, the supply and installation of cables for connections from the RTU equipment to the marshalling cabinets are included.

All terminals shall incorporate open circuiting/short circuiting links, as necessary, to permit isolation and testing of circuits to the supervisory control equipment.

3.2.8 Time Synchronization (Master Clock) not applicable

Time Synchronization (Master Clock) shall be provided for the new substations.

Time Source Synchronized with GPS satellites shall provide a complete precision time synchronization for fault recorders, events recorders, control systems and software based protective relays and other electronic devices.

It shall be complete with:

- GPS signal receiver including high gain outdoor weather-proof antenna,
- The necessary number of synchronization signals (1PPS, I RIG-B modulated/ demodulated, etc ...),
- Number of slave clocks accordingly to specifications.

3.2.9 Control & Relay Panels General

For each 33 kV switchgear cubicle, a freestanding control and protection panel shall be provided, i.e. each 33 kV circuit shall be arranged in a separate control & protection panel, unless otherwise specified in schedule A: *Scope of Supply.*

The width of the 33 kV control & protection panels shall be maximum 800 mm, unless otherwise specified in schedule A: *Scope of Supply*.

Each switchgear cubicle shall be provided with electrical control of the circuit breaker for use under maintenance or emergency conditions. A lockable selector switch shall also be provided on the switchgear cubicle labelled "local / remote".

The control and protection panel associated with each switchgear cubicle shall be provided with a lockable selector switch marked "remote / supervisory" to allow control from the National Control Centre.

Each Control and Relay cubicle shall form a complete enclosure and should be associated with only one circuit.

Cubicle arrangement shall be divided into two equal sections segregated from each other by steel sheet sectioning barriers. The upper part for Control equipment and the lower is for protection equipment. With separating all wiring and termination of each section from the other, noting that flexible conductors and wiring shall be used for connection hinged equipment and terminations.

Control and Relay cubicle shall have front access with one separate door for each section. Those doors should be separate from each other and should have glass door for relay section of control and relay panels, should have close fitting lockable and lift-off, opened through 180, hinged so that control and relay equipment movements shall be controlled to be as minimum as possible.

Relay equipment should be flush mounted in dust proof cases with filter breather.

The interior of each cubicle section shall be finished with a light-coloured paint and interior 240 V AC lamp controlled by a door-operating switch and shall be fitted at the top of each section. In addition, anti-condensation heaters controlled be thermostats are also to be fitted in each section, and each cubicle shall be well-ventilated top and bottom through vermin proof louvers fitted with brass gauze screens.

Panel degree of protection shall be IP41.

Panel exterior finish and colour of all indoor equipment and cubicles shall be RAL 6019.

Schematic drawings of control and protection circuits should be separate from each other and typical schematic for similar circuits shall not be accepted.

Equipment for each circuit shall be installed and mounted on one panel as specified and shall be erected in substation control building.

Trip links should be used as open/close terminals marked and labelled to be distinguished from other terminals, CT terminals should be of short/open terminals type and VT terminals should be of open/close terminals type.

3.2.10 Automatic Control for Capacitor Banks

The circuit breakers controlling the capacitor banks shall be closed and tripped automatically depending upon the value of the system voltage. The system voltage shall be obtained from a voltage selection scheme which selects the voltage on either of the busbars, providing that the busbar is live. Capacitor banks shall be switched-in when the voltage falls and switched-out when the voltage subsequently rises again. Typical voltage settings, in terms of nominal voltage, are 95% for switching-in capacitor banks and 100% for switching-out again. However, it shall be possible to adjust these setting values.

An automatic control panel shall be provided in each of the 33 kV switchgear control & protection panels which will control capacitor bank circuit breaker.

The automatic control system shall allow for the switching of four (4) capacitor banks. When the system voltage falls below the capacitor bank switch-in voltage level, capacitor banks shall be sequentially switched-in after a time delay as long as the system voltage remains below the switch-in level. When the system voltage rises above the capacitor bank switch-out level, capacitor banks shall be switched-out sequentially as long as the system voltage remains above he switch-out level.

The time delay shall typically be 5 seconds but shall be adjustable between 1 and 10 seconds.

Means should be provided to change the sequence of closing and tripping of capacitor bank circuit breakers so that the switching duties are shared between circuit breakers.

Automatic or manual operation shall be selectable either at the automatic control panel or from the National Control Centre (NCC). A latching relay shall be used which must be positively driven to either the automatic or manual position. The selection at the automatic control panel shall be by means of a switch automatic/neutral/manual, which shall be spring return to neutral and lockable in the neutral position. Indication of automatic/manual selection shall be given at the automatic control panel and a signal shall be sent to the NCC.

3.3 Protection Equipment

3.3.1 Protection Philosophy

The primary network shall be considered as consisting of a number of elements, the limits of each element being its associated circuit breakers.

For the 33 kV network, each element shall be provided with a single high-speed discriminative protection, capable of detecting all "credible" faults and issuing tripping commands to the associated circuit breakers within the prescribed time. The high-speed discriminative protection shall be augmented with back-up overcurrent and earth fault protection, incorporating directional characteristics and sensitive earth fault protection as necessary. Circuit breaker failure protection is required for the 33 kV circuit breakers.

High-speed discriminative protection systems shall be engineered as complete schemes, due account being taken of CT and VT performance. The defined fault clearance time shall take account of the circuit breaker response and shall include the total time to elimination of the primary fault current irrespective of the magnitude, fault location or fault current characteristic subject only to an upper limit of circuit breaker specified duty.

Attention shall be paid to the total performance including the behaviour pattern in the presence of system transients for faults "in zone", faults "out-of-zone", and during the period immediately following a switching operation irrespective of whether that operation is to eliminate a network short-circuit or is to energise or to de-energize any part of the network.

The protective equipment shall remain unoperated following the normal and correct discharge operation of one or more surge arresters.

3.3.2 Discrimination

On the occurrence of a fault on the power system network high speed discriminating protection systems shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted electrical element from the network. Protection equipment associated with adjacent electrical elements may detect the fault but must be able to discriminate between an external fault and a fault on the electrical element which it is designed to protect. Sequential time delayed tripping is not permitted except in the following specific circumstances:

- Operation of time graded back-up protection takes place as a result of either the complete failure of the communication links associated with the main protection systems, or the fault resistance is substantially greater than the value specified in this specification.
- Operation of line back-up protection to disconnect primary system faults in the case of a circuit breaker failing to operate, (i.e. circuit breaker failure protection).

All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the transmission system.

3.3.3 Construction and General Facilities

Protection systems shall preferably be accommodated in 19-inch rack or hinged rack cubicles and be of modular construction with factory assembled and tested wiring. The construction method shall offer the benefits of minimum site construction times and circuit outage requirements.

For modular protection systems, means shall be provided to lock positively each withdrawable module or unit in the "service" position. It shall not be possible to remove any module without first short-circuiting all associated current transformer circuits.

Protection relays shall be of numeric design except for high impedance differential protection relays which may be either of classic electromechanical or numeric design **upon NEPCO approval.**

Modular relays (e.g. rack mounted numeric relaying equipment) shall be tested as a complete assembly and details of such tests shall be agreed with the Client when details of the construction are known.

All relays which are accommodated in cubicles having a separate cubicle door shall be provided with individual relay covers. The intent of this requirement is to enable access to indication reset facilities without also allowing unauthorised access to relay setting adjustments.

For extension to existing installations, all new relay panels shall match the existing method of construction and installation as closely as possible.

3.3.4 Indications

Each relay or protection scheme shall be provided with an adequate number of indications to ensure that the appropriate faulted phase, zone, etc can be easily identified after a fault condition. Each indicator shall be visible and capable of being reset without removing the relay cover. Unless otherwise approved, indications shall only be given by the protection(s) causing the fault to be cleared.

Where illuminated indicators are used (e.g. light-emitting diodes) the following shall apply:

- Long term storage of the indication must not be dependent upon an auxiliary supply,
- A lamp test facility shall be provided.

3.3.5 Contacts

Each protection relay or protection scheme shall be provided with an adequate number of output contacts of suitable rating to carry out the prescribed tripping functions, alarms, indication and fault recorder functions and such supplementary signalling functions as may be necessary for the initiation of automatic reclosing or automatic switching control, etc. In all cases, contacts intended for tripping duty shall be designed so that they cannot inadvertently interrupt trip coil current.

For contacts intended to be used to energise circuit breaker trip coils directly, information shall be provided to show that the contact rating is compatible with the trip coil parameters of the associated circuit breaker. Where

appropriate, details shall also be given of the operating characteristics of any reinforcing contactor and, in particular, the pick-up and drop-off threshold levels of series connected (current dependent) contactors.

3.3.6 Numeric Relays

Numeric protection relays shall utilise numerical techniques for both measurement and logic functions and in addition to the main protection functions, shall incorporate communication, fault, event and disturbance recording, instrumentation, configurable scheme logic, alternative setting groups, self-supervision facilities and control commands.

The communication facility should allow all information available locally at the relay front panel to be accessed remotely. It shall also be possible to carry out bulk transfer of settings, fault record information etc using the appropriate PC based software.

All protection systems shall be provided with an integral local operator interface facility to enable communication with the relay without the use of external equipment. Any facilities provided for connection to an external computer shall be an additional feature to the local operator interface.

The protection relay shall also be supplied with the facilities identified below:

- Identification: Each protection system shall have a unique identifier which is clearly visible, and the software reference and issue level shall be identified.
- Settings: Each protection system shall provide a means by which the user can easily access the protection system to apply the required settings. Access to this shall be password protected. A display of the selected settings shall be provided on the protection system.
- Indications: Each protection system shall provide indications as specified in the appropriate second level protection system specification.

The Contractor shall be obliged to provide adequate compatibility between protection relays and corresponding current transformer cores and shall submit all necessary calculations and analysis as evidence to Client for approval.

3.3.7 Trip Circuit Supervision and Auxiliary Supply Monitoring

Means shall be provided to continuously supervise the integrity of the circuit breaker tripping circuits and give an alarm in the event of the following fault conditions:

- Loss of DC tripping supply, e.g. removal of DC trip fuse,
- An open circuit in the trip circuit including the trip coil, circuit breaker auxiliary switch and all associated connections (supervision to be effective with the circuit breaker in either the open or closed condition).

The alarm shall be time-delayed preventing it operating during momentary dips in the DC supply. The alarm shall also be inhibited when the circuit breaker auxiliary switch interrupts the trip coil circuit, on circuit breaker opening.

All DC auxiliary supplies, essential for the operation of the protection relay scheme shall be monitored and the loss of any supply shall be indicated on the relay panel and an alarm given.

3.3.8 Commissioning and Routine Testing Facilities

Each functional relay scheme shall be so arranged that operational and calibration checks can be carried out with the associated primary circuit(s) in service.

Adequate test facilities shall be provided within the protection system to enable the protection and auto-reclosing equipment to be tested from the front of the protection equipment with the primary circuit(s) in service.

Adequate facilities shall be provided to isolate all DC and AC incoming and outgoing circuits so that work may be carried out on the equipment with complete safety to personnel and without loss of security in the operation of the switching station.

All test equipment required for commissioning and routine testing of the offered protection equipment shall be listed in the tender documents. Where test equipment is specified, it shall include such injection transformers, test leads and plugs as are necessary to carry out secondary injection tests on each type of relay scheme and, for the more complex schemes, such special test equipment as may be necessary to verify the accuracy of timing and verify the effective operating characteristics of the equipment. **(not applicable, just test leads and test plugs)**

For numeric equipment, such test equipment as may be required to carry out on-site investigation into the performance of individual modules or printed circuit cards shall be listed in the tender documents. At least one complete set of any special test equipment shall be included within this Contract together with such additional connections, dummy extension boards, etc as may be necessary. **(not applicable)**

3.3.9 Relay Settings

Not less than 6 months before commissioning, suitable settings shall be recommended for all relays and protection to be supplied for all substation equipment (excluding OHL and cables). The recommended settings will ensure satisfactory operation in accordance with the intent of this Specification and the specified system operating conditions. The recommended setting shall not only include those normally available on the front of a relay but also the positions/settings of any internal links, plugs, etc not normally adjusted after installation. These settings shall be applied to the equipment prior to performing the commissioning tests. The settings for line protection shall be such as to permit correct operation of the protection for earth faults up to 100 ohms fault resistance. Any limitations imposed on the power system as a result of the settings proposed shall be explicitly stated, settings regarding capacitor banks to be provider from the manufacturer, The used relays should be suitable for handling multi-stage settings at the same type.

3.3.10 Environmental Requirements

3.3.10.1 Temperature

The standard nominal range of ambient temperature shall be -10°C to +55°C.

The protection system shall operate satisfactorily when tested to the following requirements:

- IEC Publication 60068-2-1 with severity class -10°C, 96 hours,
- IEC Publication 60068-2-2 with severity class 55°C, 96 hours

The protection system shall be able to withstand the temperature requirements for storage and transportation and shall be tested to the following requirements:

- IEC Publication 60068-2-1 with severity class -25°C, 96 hours,
- IEC Publication 60068-2-2 with severity class 70°C, 96 hours.

3.3.10.2 Relative humidity

The protection system shall operate correctly with a relative humidity of 93 per cent and shall be tested to IEC Publication 60068-2-78 with severity class 56 days.

3.3.10.3 Enclosure

The protection relay shall meet the requirements of the tests detailed in IEC Publication 60529 with classification IP50 (dust protected). If the individual enclosure of the relay is to a class less than IP50 then the Tenderer shall provide a cubicle to classification IP50 to accommodate the relay.

3.3.11 Mechanical Environment

3.3.11.1 Vibration

The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-1 with severity class 1.

3.3.11.2 Shock and Bump

The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-2 with severity class 1.

3.3.11.3 Seismic

The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-3 with severity class 1.

3.3.12 Electrical Environment

3.3.12.1 DC Auxiliary Energising Quantity

The protection systems shall be capable of being energised from a DC auxiliary energising voltage of 110 V (nominal).

The protection system or its associated power supply for use in a 110 V (nominal) DC supply system shall operate correctly over a voltage range of 88 V to 137.5 V and shall withstand a maximum voltage of 143 V.

Numeric protection systems shall meet the requirements of IEC Publication 60255-26 with interruptions to the DC auxiliary energizing quantity of 10 ms.

3.3.12.2 Frequency

The standard rated frequency shall be 50 Hz.

The nominal range of frequency shall be -5 per cent to +5 per cent.

3.3.13 Insulation

3.3.13.1 Rated Insulation Voltage

The rated insulation voltage of circuits connected to current transformers of high impedance relays shall be 1000 V. All other circuits shall have an insulation voltage of 250 V.

All open contacts of the protection system shall withstand a voltage of 1000 V.

3.3.13.2 Dielectric Tests

The protection system shall comply with the dielectric test requirements of IEC Publication 60255-27. The test voltage shall be selected according to the rated insulation voltage of the circuits being tested form Series C of Table 1 of IEC Publication 60255-27.

3.3.13.3 Impulse Voltage

The protection system shall comply with the impulse test requirements of IEC Publication 60255-27 with test voltage of 5 kV.

3.3.14 Electromagnetic Compatibility.

The requirements of this section of the specification are specifically applicable to numeric protection systems. The requirements may also be applied to some electro-mechanical relays that are very sensitive or of high speed, at the discretion of the Client.

3.3.14.1 1 MHz Burst Disturbance

The protection system shall comply with the requirements of IEC Publication 60255-26 with severity Class III.

3.3.14.2 Electrostatic Discharge

The protection system shall comply with the requirements of IEC Publication 60255-26 with severity Class III.

3.3.14.3 Radiated Electromagnetic Field Disturbance

The protection system shall comply with the requirements of IEC Publication 60255-26 with severity Class III. The test shall be carried out by using Test Method A and by sweeping through the entire frequency range 27 MHz to 500 MHz.

3.3.14.4 Fast Transient Disturbance

The protection system shall comply with the requirements of IEC Publication 60255-26 with severity level IV.

3.3.15 Thermal Requirements

The requirements of this section apply to protection systems rated at 1 A associated with line circuits where the load current is carried by current transformers which supply the protection system.

The protection systems shall have a minimum continuous thermal withstand of 2.4 A.

The thermal withstand currents for short duration overloads, after having reached a steady temperature with an input current of 2.0 A, shall not be less than given in the table shown below.

Duration (mins)	20	10	5	3	2
Current (amps)	2.5	3.5	4.0	5.0	6.0

3.3.16 Inverse Time Overcurrent and Earth Fault Relays

Inverse time overcurrent and earth fault relays shall be of the numeric type and shall have selectable characteristics, i.e. normal inverse, very inverse and extremely inverse.

The operating time characteristic shall be continuously variable over the minimum range 0.1 to 1.0 times the nominal time at any multiple of current setting.

The current settings shall be adjustable as a percentage of nominal relay rating over setting ranges which are at least:

- Overcurrent relays: 50 to 250%,
- Earth-fault relays: 10 to 80%.

The actual relay pick-up current shall not exceed 1.3 times the relay setting, and the reset value shall not be less than 90 per cent of the pick-up current.

All relays shall comply with the accuracy requirements of IEC 60255, the required class index of the reference limiting error being 5.

3.3.17 High Set Overcurrent, Instantaneous Overcurrent and Earth Fault Protection

High set overcurrent, instantaneous overcurrent and earth fault protection shall be of the high-speed type and provided with a current independent selectable time delay with a setting range from instantaneous (no intentional time delay) to 100 secs in steps of 0.01 secs.

High set over current elements shall be of the low transient overreach type, i.e. the magnitudes of the current with and without the presence of a DC transient at which operation occurs shall be approximately the same. The value of the system reactance to resistance ratio at which the performance of the element is claimed should be stated. When applied to the protection of power transformers, high set overcurrent elements must be capable of being set to remain stable for maximum through fault currents associated with faults across the remote winding terminals.

3.3.18 Directional Overcurrent and Earth Fault Relays

Directional relays may either be provided as separate relays or as part of an overcurrent or earth fault inverse time relay combination.

A range of characteristic angle settings shall be provided so that correct directional discrimination will be achieved for all credible system faults. Preference will be given to relays in which voltage polarising, current polarising or dual polarising can be achieved.

Where directional features are applied to overcurrent and earth-fault inverse-time relays, the following requirements apply:

- The operating time of the directional element shall have negligible influence on the total operating time of the composite relay,
- The current setting of the directional element shall be low enough so as not to increase the overall setting of the composite relay for all faults in the operate direction,
- The angle setting of the directional element shall be selectable.

3.3.19 Overcurrent and Earth Fault Definite Time Delay Relays

Preference will be given to relay designs in which the current settings for phase-to-phase faults are the same as those for three phase faults and in which the current settings for single phase to earth faults are the same irrespective of the phase involved.

The current measuring elements shall be of the low transient overreach type and the value of the system reactance to resistance ratio at which the transient overreach performance claim is made shall be stated. Their operating time shall be less than 30 milliseconds at 5 times setting and their drop off to pick up ratio shall not be less than 90 per cent.

The associated timing relay shall have a timing range (or ranges) adjustable between 0.1 and 10 seconds minimum, the setting adjustment being either continuous or stepped, with a maximum of 20 milliseconds per step. The accuracy of setting shall be at least ± 5 per cent of setting or 20 milliseconds whichever is the greater.

3.3.20 Circulating Current Protection

The principle of operation of the circulating current protection shall be based upon the well-known differential, current balance system with high impedance type relays.

The protection shall remain unoperated for all out of zone fault currents ranging from 0 to 15 times full load rating of the protected circuit and all other system transient conditions, such as inrush currents, which are not due to internal faults.

Definite operation shall occur for faults between windings of different phases involving as few turns as is practical within the fault loop. A setting of 10 per cent or less is preferred.

The operating time shall be 30 ms or less at 5 times setting.

3.3.21 Tripping Relays

The tripping relays shall be of the low burden, multi-contact type.

All multi-contact tripping relays shall be suitable for panel mounting. The design of the operating coil shall be such as to permit operation in conjunction with series trip flag relays should these be specified. When provided on the relays, economy contacts used to reduce the level of energisation of the operating coil after operation shall be delayed in operation sufficiently long enough to ensure that series flag relays operate correctly.

All contacts shall operate within the prescribed time for the particular category which shall not, in any case, exceed 10 milliseconds from the time at which the operating coil is first energised to the time of complete contact closure.

Tripping relays shall be with flags and shall be of the mechanically latched type and shall be self-reset or electrical/hand reset type as specified.

3.3.22 Circuit Breaker Failure Protection

The purpose of circuit breaker fail protection is to clear a fault which has been correctly detected by the appropriate protection but for which the associated circuit breaker(s) has (have) failed to open.

In the event of a circuit breaker failing to operate, the circuit breaker fail protection shall be arranged to trip all circuit breakers capable of feeding fault current to the faulted circuit. For this purpose, the tripping circuitry of busbar protection may be used. Inter tripping shall also be initiated where appropriate.

Two basic criteria shall be satisfied before tripping can take place. Fault current must be flowing, and the appropriate protection must have failed to reset within a pre-set time. Initiation of a circuit breaker fail trip condition should therefore be dependent on both the pre-set time elapsing and the current detecting elements being operated, outputs from both these functions being effectively connected in series.

A time delay shall be available to provide the pre-set time delay. This shall have facilities for continuous adjustment of time over the range 50 - 500 ms unless it is clearly shown that the range of settings provided is sufficient to meet the particular application requirements.

The current detecting elements shall have settings which are low enough to ensure correct operation during minimum plant conditions. The settings shall be equal to or lower than the settings of the associated protection.

The continuous current rating of the current detecting elements shall be at least twice their nominal current rating, the current settings selected being the lowest available.

The resetting time of the current detecting elements on cessation of fault current shall not be greater than 20 ms. The current detecting circuits must be arranged so that, when single pole tripping is specified, correct operation of the scheme occurs during the dead time, i.e. the presence of load current in the healthy phases should not cause maloperation operation of the scheme.

3.3.23 Manual Synchronising Facilities

The following equipment, plus any additional auxiliary equipment necessary to ensure correct functioning of the scheme, shall normally be provided:

- A socket into which a synchronising trolley plug must be inserted. This shall enable the appropriate incoming and running supplies to be applied to a check synchronising relay and synchronising instruments. The insertion of the plug also prepares for closure of the circuit breaker via the discrepancy control switch and a contact of the check synchronising relay.
- A check synchronising relay as specified in the appropriate section of this Specification. Where check synchronising relays for manual synchronising are provided, these may be utilised for auto-reclose requirements. A guard feature shall be provided to ensure that the check synchronising relay contact is closed before the closing switch is operated to close the circuit breaker. If the closing switch is operated before the check synchronising relay, contact closes then circuit breaker closing should be prevented. A facility should also be included to detect welding or permanent closure of the synchronising relay contacts and prevent closing of the circuit breaker.
- Interposing transformers for incoming and running voltage supplies. Phase to neutral voltages shall be used for synchronising purposes and the synchronising equipment shall operate satisfactorily over the range of 80 to 120 per cent of its rated value.
- Voltage selection equipment, either auxiliary contacts from primary equipment or voltage selection relays, where specified.
- Synchronising instruments consisting of incoming and running voltmeters, frequency meters and synchroscope. These instruments shall be continuously rated.

A synchronising trolley, containing the common synchronising equipment together with cable and plug is required.

DBC/DLC interlocks. If check synchronising is provided, closure of a circuit breaker interconnecting two circuits may be required where the conditions for synchronising cannot be satisfied due to the absence of either running or incoming supply. In these cases, and where specified, Dead Line Check (DLC), Dead Bar Check (DBC) and "Synchronising Override" interlocks shall be provided.

A DBC interlock permits reclosure only if the busbar is de-energized on all three phases. A DLC interlock permits reclosure if the associated line is de-energized on all three phases. In both cases the opposite supply to that which is de-energized must be energized. A busbar or line is considered to be de-energized when the voltage is less than 20 per cent of rated voltage and considered to be energized when at least 80 per cent of rated voltage.

A key interlocked check synchronising override switch per circuit breaker shall be provided to enable the contact of the check synchronising relay in the closing circuit to be by passed. Operation of this switch shall be interlocked with the voltage interlocks of DBC or DLC above, to prevent override of check synchronising unless one or both voltage supplies are absent.

3.3.24 Check Synchronising Relay

Check synchronising relays shall be provided as specified to enable a check of synchronism between appropriate incoming and running voltages for manual and automatic reclosure of each circuit breaker.

Measurement of the following parameters of incoming and running voltages must be provided:

- Phase angle difference. Adjustment of the phase angle between incoming and running voltages over which the relay contacts will close shall be provided over the range 20°to 45°. (Note this results in a total angular segment over which circuit breaker closure is permitted of 40° minimum to 90° maximum).
- Rate of change of phase (slip). The maximum slip frequency at which closure is permitted is a function of circuit breaker closure time and adjustment shall be provided for this. The method of measurement of slip in which it is ensured that the true phase angle difference does not exceed the set phase angle difference for more than a given time, is preferred. A time range of 2 to 10 seconds is required. Alternative methods, e.g. direct instantaneous measurement of true slip frequency, are permitted and a range of settings of 0 to 0.125 Hz/sec is required. If the preferred measurement method is not used, a timer shall be provided so that at least 2 seconds must elapse between application of both ac supplies to the check synchronising relay and an output being given.
- Voltage difference. A voltage check feature shall be incorporated which shall inhibit operation of the check synchronising relay if either one or both of the synchronising voltages is less than a pre-set percentage of rated voltage. The voltage check feature shall be adjustable over the range 80 per cent to 90 per cent of the relay rated voltage.

3.3.25 33 kV Feeder (Cable/OHL) Protection

3.3.25.1 Numerical Line Differential Protection

Line differential protection relays shall preferably utilise the phase segregated current differential principle and shall be suitable for use with both dedicated optical fibre links, or multiplexed communication systems. The relay shall provide phase selective differential protection for two terminal lines and shall operate simultaneously at both terminals of the protected circuit to provide rapid fault clearance irrespective of whether the fault is fed from both terminals or from one end of the line only.

High speed tripping for all in-zone faults, stability for all out-of-zone faults and correct operation for developing faults must be assured for all practical conditions of load and fault current flow.

The line differential protection relay shall operate correctly for all in-zone phase-to-phase and phase-to-earth faults occurring at the same time, or shortly after, an out of zone fault, and for all other types of evolving faults

Relay operating time shall not exceed 30 ms with fault resistance up to 100 ohms.

Relay reset time, from cessation of any condition, which would cause the relay to operate, shall not exceed 100ms.

The returning ratio, defined as the differential current at which the relay resets divided by the differential current at which the relay operates, shall not be less than 70%.

The relay shall continuously monitor the propagation delay of the communication channel used for transmission of the protection measurement quantities and shall provide compensation for the effects of the propagation delay. The relay shall continuously adjust the propagation delay compensation to the prevailing delay value such that automatic re-routing of the communications channel does not cause incorrect operation of the protection relay.

Each relay shall be uniquely addressable; so that if it receives incorrect messages (e.g messages from the wrong remote relay, or messages are looped back to itself via the communications channel) as a result of incorrect operation of the communications channel, the incorrect messages will be rejected, and the relay will not mal-operate.

The line differential protection relay shall provide an inter-trip facility to enable a relay at the remote end to be energized via the communications channel used for the line differential protection, when a relay contact at the local end is closed. This facility shall be available to be assigned to any trip or signalling function such as direct transfer trip or block auto-reclose.

The line differential protection relay shall provide a permissive inter-trip facility to enable a relay at the remote end to be energized via the communications channel used for the line differential protection, when a relay contact at the local end is closed and the current detected by the remote end line differential protection is above the threshold level for operation.

The line differential protection shall incorporate indicators to show: Relay operation, Inter-trip operation, Permissive inter-trip operation, Relay out of service, Relay available. Indication must not be lost in the event of a supply failure.

Supervision facilities which include a periodic self-check of the key elements within the relay and a continuous self-monitoring of all internal power supplies, microprocessor operation and communication equipment shall be provided. The indications provided shall be designed to allow the defective item to be quickly identified. The status of the DC power supplies shall be permanently indicated. A defect in any of the self-supervision facilities shall not cause mal operation of the protection relay.

The line differential protection relay shall include facilities for the storage of fault records. A minimum of four records shall be capable of being stored in non-volatile memory within the relay for post-fault analysis.

The line differential protection relay shall be compatible with as wide a range of communication equipment and media as possible, and to achieve this the relay shall be designed to operate within the signalling bandwidth of a basic 56/64 kb/s pulse code modulated (PCM) signalling channel.

The relay shall be capable of providing redundancy of communication by transmitting and receiving messages over two communication channels, both of which are continuously monitored by the relay. If one channel fails, the relay shall continue to operate correctly over the remaining channel.

The relay shall be capable of operating over a dedicated optical fibre communication channel, or over a digital communication channel which is multiplexed and shared with other protection and telecommunications equipment employing optical fibres or conventional media. The design of the protection relay shall preferably be such that the various communication channel requirements can be accommodated within the relay with only the communication interface requiring to be changed to suit different requirements.

3.3.25.2 *Pilot Wire Differential Protection*

Pilot wire differential protection shall be provided where specified and shall be of an approved type employing preferably not more than two (2) cores in a multicore pilot cable with 1/0.9 mm telephone conductors. Other cores in the same cable may be used for remote control equipment, tele-metering, high speed inter-tripping and speech channels, all of which are to operate satisfactorily and without mutual interference with the feeder protection.

The protection shall operate for phase faults and earth faults within the protected zone and remain stable for through faults equal to the maximum rated breaking capacity of the associated switchgear.

Phase and earth fault sensitivities shall not be more than 125% and 45% respectively of the nominal rated load of the circuit operating time characteristics shall be stated.

Pilot wire supervision facilities shall monitor the pilot circuit via a spare pair of pilot cores. All necessary associated pilot isolating transformers, power supply units and insulated supervision relays shall be provided. Overcurrent and earth fault guard relays of the instantaneous type having setting ranges of 50% ÷ 200% of CT nominal current for overcurrent relays and 10% ÷ 40% of CT nominal current for earth fault relays.

Relay and associated equipment insulation shall be at least 15 kV.

3.3.25.3 *Sensitive Earth Fault Protection*

Sensitive earth fault protection shall be provided to cater for high resistance earth faults which remain undetected by the main protection and shall comprise a definite time overcurrent relay.

The current setting shall be adjustable between 3 and 5% of CT rated secondary current. The time delay shall be adjustable between 1 and 10 seconds.

As the relay has a very low setting, it is essential that the burden imposed by the relay is small.

3.3.25.4 33 kV Delayed Automatic Reclosing Relays

Three phase single shot delayed automatic reclosing equipment shall be provided for all 33 KV overhead line feeders. Reclosure shall be initiated by the instantaneous overcurrent and earth fault relay elements incorporated in the overcurrent and earth fault relays. During the dead time, the auto reclose relay shall interrupt the instantaneous element trip circuits so that if the fault is permanent, the circuit breaker shall be tripped by the inverse time relays and a second reclosure will not take place. Reclosure shall not be initiated in the event of an operation of the sensitive earth fault relay or when the circuit breaker is closed onto a fault on a previously de-energized line.

The dead time following fault clearance shall be adjustable between 3 and 30 seconds. The reclaim time, i.e. the time following automatic reclosure during which further faults result in tripping and lockout, shall be chosen to match the circuit breaker duty cycle assuming the shortest available dead time is selected. The reclaim time shall however, be adjustable between 5 and 200 seconds.

The closing command shall be limited to 2 seconds after which time the reclosing equipment shall automatically reset.

A counter shall be provided to record the number of tripping and lockout the equipment after a pre-selected number of operations. An alarm shall indicate when the "lockout for maintenance" situation is approaching.

A switch shall be provided to switch the auto-reclose equipment in or out of service.

3.3.26 Transformer Protection

3.3.26.1 Low Voltage (LV) Restricted Earth Fault (REF) Protection

Transformer windings with YN connection shall be provided with LV restricted earth fault protection. Relay shall be of the high impedance circulating current type necessary protection against over-voltage.

The sensitivity of the protection scheme shall not exceed 25% of the rated current of the protected winding in the case of solidly earthed systems and 15% of the minimum current available for an earth fault at the transformer terminals in the case of resistance earthed systems. These values are to include the effect of current transformer magnetising current and the current taken by the voltage limiting device.

The protection shall remain stable up to the maximum through fault current corresponding to the rated system short circuit level. This may be taken as 16 times the rated current of the protected winding of the power transformer, unless otherwise approved by the Client.

Associated current transformers shall be class X (PX according to IEC 61869-2), or other class as recommended by the relay manufacturer and approved by the Client. Contractors shall submit at an early stage, design calculations for current transformers for approval.

3.3.26.2 Transformer Cable Circulating Current

The transformer cable circulating current relay shall be used for each transformer circuit (where capacitors are connected to the 33 kV transformer side), as follows:

- The protected zone is the 33 kV cable from the transformer to the indoor 33 kV transformer CB,
- The CT secondary from the transformer outdoor 33 kV CTs, transformer indoor 33 kV CTs shall be supplied to the relay,

- Instantaneous tripping for all dedicated CBs,
- Relay ratings:
  - Operating time: ≤ 30 ms,
  - The relay shall be low burden,
- Features of the relay:
  - Operation of the relay shall be based on low impedance differential protection principle which operates with all CTs types & classes,
  - The relay shall be supplied with a numerical display, showing continuously & instantaneously magnitude and phase of each current,
  - The relay shall be insensitive to voltage fluctuation, harmonics, and transients on the network,
  - The relay shall be stable during capacitor operations,
  - The relay shall be suitable to be used for inputs with different CT ratios & different CT classes (5P10/20/30),
  - The relay shall be stable for all out-zone faults, even for 20×In,
  - Signalling LED for operation of the relay,
  - Self-check watch dog shall be provided.

3.3.26.3 Transformer Tripping Scheme

Tripping circuits with its own electrical/hand reset tripping relay and DC supply shall be provided. The transformer protection tripping circuit shall be arranged as follows:

Both 132 kV & 33kV circuit breakers shall be tripped by the following relays:

- Biased differential,
- Over-flux protection,
- HV restricted earth fault,
- HV over current,
- 132 kV busbar protection,
- LV restricted earth fault,
- HV Stand-by earth fault protection,
- Buchholz surge of the main and earthing/auxiliary transformers,
- HV earth fault,
- Tap changer surge (main Transformer),
- Pressure Relief valve.

The 33 kV circuit breaker only shall be tripped by the following relays:

- Winding Temperature - stage 2,
- Oil temperature - stage 2,
- Directional overcurrent,

- 33 kV busbar zone protection,
- LV earth fault.

The 33 kV stand by earth fault relay shall trip:

- The 33 kV transformer incomer circuit breakers on stage 1,
- The 132 kV transformer circuit breakers on stage 2.

The 132 kV circuit breakers are equipped with duplicate tripping coils; only one trip coil is allocated for protection tripping functions. Each trip relay shall operate into the 132kV trip coil allocated for protection functions, i.e. each 132 kV circuit breaker shall receive a total of two trip commands.

The winding temperature trip devices shall be arranged to trip the appropriate circuit breaker only, i.e. HV and LV winding temperature shall trip the LV breaker only.

3.3.27 High Impedance Busbar protection

The busbar protection shall operate for both phase to phase and phase to earth faults. The principle of operation shall preferably be based on the simple circulating current system with high impedance relay circuits. The operating time of the measuring relays shall not exceed 30 msecs at five times the relay current setting.

The equipment shall be stable for all out of zone phase to phase and phase to earth fault currents up to the short circuit current rating of the switchgear, applied gradually or suddenly and irrespective of the distribution of current between the individual circuits.

There shall be fully discriminative clearance of busbar faults on any section of busbar without introducing sequential tripping of coupler or section circuit breakers. All circuit breakers connected to a faulty busbar shall be tripped simultaneously, whether they feed fault current or not.

Care shall be taken to ensure that the protection does not maloperate as a result of faults in the associated secondary wiring when the primary circuit is carrying load current. Continuous or automatic cyclic supervision shall be provided for this purpose. Arrangements shall be provided to make the zone containing the faulty circuit inoperative. Where the operation of the supervision device is dependent upon the load current in the primary circuit, operation shall occur at current of 25 amperes or 10% of the circuit rating whichever is the greater.

The following test and isolation facilities shall be provided on the front of the protection panel:

- Short circuiting and isolation of current transformers,
- Isolation of individual tripping and inter tripping circuits,
- Isolation of tripping and individual zones.

Inter-tripping, where required, shall be affected by means of electrically separate outputs. The inter-tripping scheme shall be a subject of Client's approval.

The sensitivity shall be such that definite operation occurs for phase to phase and phase to earth short circuits during minimum plant conditions, irrespective of the number of circuits in service and the distribution of load and fault currents. The sensitivity level shall not exceed 30% of the minimum fault level for all types of faults.

Isolator auxiliary switches employed in current transformer circuits shall be of the heavy duty; silver plated type and two switches in parallel shall be used per current transformer connection.

The Contractor shall clearly specify the number of secondary circuits which must be switched, the duty of the switches and the timing between individual switches; the Contractor shall be responsible for selecting switches which are adequate for the intended duty.

The busbar protection shall have the following features:

- Two (2) independent systems (Discriminating and Check) fed from separate CTs, shall be provided for each busbar section. The Discriminating system associated with each busbar section is unique, however the Check system is common to all busbar sections. Each system shall be capable of detecting all types of faults under all system generation conditions,
- Each system shall comprise a single relay connected in parallel across busbar protection CT bus wiring. The Check system shall be connected in parallel across the busbar protection CT bus wiring associated with all incomers and feeders, the Discriminating system shall be connected in parallel across the busbar protection CT bus wiring associated with the bus coupler and bus section and only with circuits connected to a particular busbar section. Coincident operation of one Check system relay and one Discriminating system relay shall be arranged to initiate tripping of the appropriate busbar section,
- Shall be provided with a single busbar protection tripping system. Contacts on the appropriate the Check and Discriminating system relays shall be connected in a series arrangement so that coincident operation of one Check system and one Discriminating system relay is necessary in order to initiate tripping of the appropriate busbar,
- A single hand reset busbar protection trip relay shall be provided for each circuit breaker with the exception of the bus coupler and bus section circuit breakers which shall be provided with two hand reset busbar protection trip relays, one for each discriminating zone of busbar protection. The busbar protection tripping system may also be used for back tripping from the circuit breaker failure protection.

3.3.28 Low Impedance Busbar protection

The Low Impedance busbar protection shall operate for both phase to phase, 3 phase and phase to earth faults. The principle of operation shall preferably be based on low impedance differential protection. The operating time of the relays shall not exceed 30 msecs at five times the relay current setting.

The equipment shall be stable for all out of zone phase to phase, 3 phase and phase to earth fault currents up to the short circuit current rating of the switchgear, applied gradually or suddenly and irrespective of the distribution of current between the individual circuits.

There shall be fully discriminative clearance of busbar faults on any section of busbar without introducing sequential tripping of section circuit breakers. All circuit breakers connected to a faulty busbar shall be tripped simultaneously, whether they feed fault current or not.

Care shall be taken to ensure that the protection does not maloperate as a result of faults in the associated CT wiring when the primary circuit is carrying load current. Continuous or automatic cyclic supervision shall be provided for this purpose. It shall be possible to make the zone containing the faulty circuit inoperative and/or to bring up an alarm. Where the supervision is dependent upon load current in the primary circuit, operation shall occur at a primary current of 25 amperes or 10 per cent of the circuit rating whichever is the greater.

The following test and isolation facilities shall be provided on the front of the protection panel:

- Isolation of individual tripping and inter tripping circuits,
- Isolation of individual zones.

Inter tripping, where required, shall be affected by means of electrically separate outputs contacts of the trip relay. The inter tripping scheme shall be to the approval of the Client.

The Bus bar protection shall be capable of operating with class P CTs.

The sensitivity shall be such that definite operation occurs for phase to phase and phase to earth short circuits during minimum plant conditions, irrespective of the number of circuits in service and the distribution of load and fault currents. The sensitivity level shall not exceed 30 per cent of the minimum fault level for all types of faults.

The busbar protection shall have the following features:

- A single hand reset busbar protection trip relay shall be provided for each circuit breaker with the exception of the bus section circuit breakers which shall be provided with two hand reset busbar protection trip relays, one for each discriminating zone of busbar protection.
- The busbar protection tripping system may also be used for back tripping from the circuit breaker failure protection.
- Signalling lamp for each Zone (i.e. Bus Bar protection operated for each Zone, Busbar protection fail for each Zone, DC healthy, Busbar protection in/out of service for each zone…).
- Features of the Low impedance busbar protection relay:
  - Input currents to be 1 A secondary,
  - The relay to be low burden,
  - The relay to be supplied with a numerical display, showing the magnitude and phase of each current,
  - The relay to be insensitive to harmonics, and transients on the network,
  - Parameters and settings shall be able to be changed from the local interface & by computer access,
  - The relay should be stable during busbar selector switching operations,
  - The relay shall have Self-test capability with a watchdog contact.

3.3.29 Standby Earth Fault Protection

Standby earth fault protection shall be provided for all resistors, fed from a current transformer in the resistor connection.

The protection shall comprise a two-stage definite time overcurrent relay. The operating current shall be adjustable between 10 and 40 per cent of the resistor value. The two-time delay stages shall be adjustable between 1 and 10 seconds. As an alternative to a definite time delay, and with the approval of the Client, a long inverse time relay may be offered together with a second stage timer.

3.3.30 Under Frequency Load Shedding

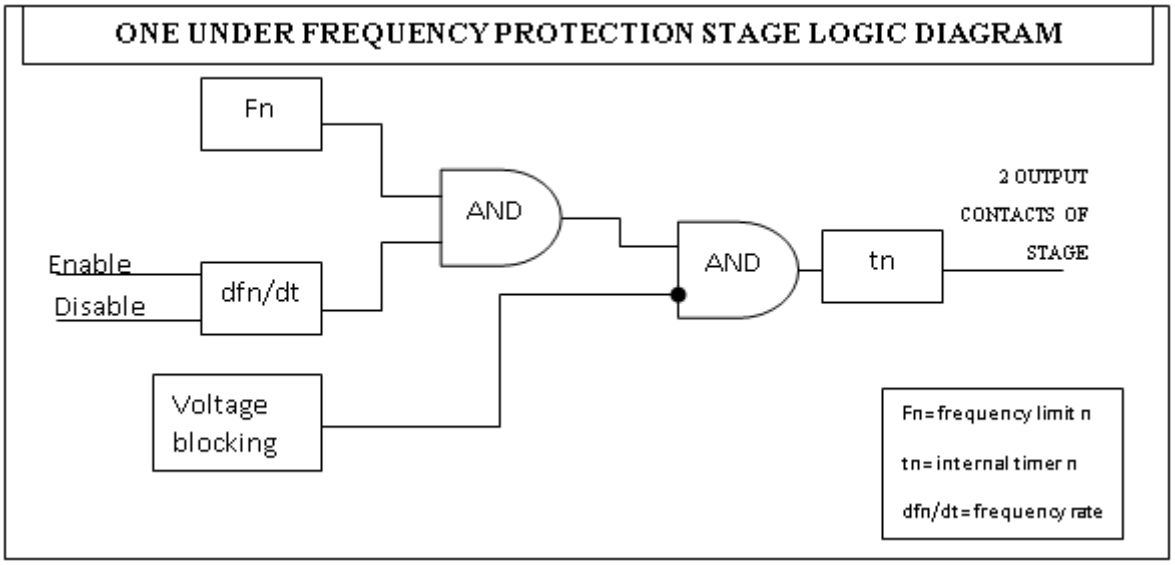
The load shedding scheme shall consist of one (1) cubicle located in 33 kV Control & Protection room, which includes load shedding relays and voltage selection relays, as the following:

- Voltage selection scheme (AC voltage inputs from 33 kV VT secondary 110 AC for each Transformer Circuit, AC voltage output is to be used to supply UF relays),
- Under frequency relays with at least of 16 stages (one relay or multiple relays) of independently settable frequency & df/dt,
- The tripping commands shall be sent to all 33 kV feeders, through fuse links to trip the CBs,
- Alarm facia/display shall be included.

Each under frequency relay shall have the following characteristics:

- Relay ratings:
  - Frequency setting range: 40 to 60 Hz, step of 0.05 Hz,
  - Frequency rate of change setting range: 0 to-10 Hz/sec, step 0.05 Hz/sec,
  - Time setting range: 0 to 20 sec., step 0.01 sec,
- Features of the under-frequency relay:

- Measure the frequency and its rate of change with respect to time,
- The relay shall be supplied with a numerical display, showing continuously & instantaneously network frequency,
- Self-check watch dog shall be provided,
- The relay shall be insensitive to voltage fluctuation, harmonics and transients on the network,
- Internal settable minimum voltage blocking,
- Minimum two (2) output contacts for each stage tripping (totally 32 output contacts),
- Additional two (2) output contacts for alarming and signalling,
- Keypad access to enable setting, resetting, …etc., of the relay,
- Facility to switch the relay ON/OFF, and test output contacts,
- Each stage shall have an independent setting for frequency, time and frequency rate of change,
- Each stage shall have an independent LED showing the stage operation,
- Each stage shall include the following functions (as per the following diagram):



Each voltage selection relay shall have the following characteristics:

- The relay shall be supplied by two (2) AC voltages, one as main supply and the other as alternative supply,
- The relay shall be used to switch-on automatically the alternative supply if main supply fails.

3.3.31 Capacitor bank protection

The following protection functions shall be enabled for protection of capacitor banks:

- Current unbalance protection - Each capacitor bank shall have a two-step current unbalance protection, the first step of which initiates alarm and the second of which trips the associated circuit breaker. The Contractor shall recommend the necessary current and time delay ranges and settings. The settings shall allow for uneven temperatures and tolerance of capacitance,
- Phase and earth fault inverse time overcurrent protection - The protection shall be an inverse time relay, which shall initiate tripping of the bank, associated 33 kV circuit breaker,

A circuit breaker failure function shall be included in the relay of phase and earth protection,

The CBF shall initiate tripping of associated 132 kV transformer circuit breaker and bus section circuit breakers; the timer of the CBF function shall be adjustable,

High set elements of the inverse time relays shall trip the associated capacitor bank circuit breaker. The Contractor shall ensure that the available setting range is wide enough to allow a selection of a setting higher than the maximum possible charging current of the capacitor banks,

- No volt protection to disconnect the capacitor bank instantaneously in the event of power supply interruption,
- Overvoltage protection with an inverse time characteristic to match the overvoltage characteristics of the capacitor bank,
- Overload protection with an inverse time characteristic.

The Contractor shall provide a comprehensive calculation to demonstrate the co-ordination and performance of the various protection levels (fuses, current unbalance protection and overcurrent and earth fault protection) under the normal, switching and fault conditions including the recommended settings.

3.3.32 Combined Protection Relays for 33 kV Circuits

Combined protection relays for 33 kV circuits are acceptable only as follows:

33 kV OHL Circuit

Item	Protection Function
1	Over current / Earth fault / Sensitive Earth Fault / Circuit breaker failure
2	Synchro check / Auto reclose
3	Self-reset trip relay
4	Trip circuit supervision

33 kV Cable Circuit

Item	Protection Function
1	Cable differential
2	Over current / Earth fault / Synchro check / Circuit breaker failure
3	Electrical reset trip relay
4	Trip circuit supervision

33 kV Transformer Circuit

Item	Protection Function
1	LV Restricted Earth Fault
2	Directional Over current / Earth fault / Synchro check / Circuit breaker failure
3	Electrical reset trip relay
4	Trip circuit supervision

33 kV Bus Section

Item	Protection Function

1	Over current / Earth fault / Synchro check / Circuit breaker failure
2	Self-reset trip relay
3	Trip circuit supervision
	Neutral Earthing Resister
Item	Protection Function
1	Stand-by Earth Fault protection
	33 kV Capacitor Banks
Item	Protection Function
1	Over current / Earth fault / Overload / Over voltage / Under voltage / Circuit breaker failure
2	Unbalance Current
3	self reset trip relay
4	Trip circuit supervision

Communication standard (IEC 61850) shall be included in protection relays.

3.4 Energy Meters

3.4.1 Main Characteristics

Energy meters shall be fully designed and manufactured in accordance with all applicable/related IEC standards.

Meter approvals and certifications shall be from internationally recognized and accredited laboratories only. A copy of each Certificate relating to meter approval/compliance shall be submitted.

For the purposes of this Tender, the required accuracy class for all active energy measurement shall be Class 0.2S, and for reactive energy measurement accuracy class shall be 0.5S.

Energy meters shall function normally in the following conditions:

- Ambient temperature: -5 °C to 50 °C,
- Storage conditions: between 0 °C and 30 °C,
- Humidity: 75%.

Energy meters shall have the following electrical characteristics:

- Nominal voltage (Un):
  - Measuring circuits (from voltage transformer): 3×100/120 V AC,
  - Auxiliary circuits (Universal auxiliary power supply): 1×85 ÷ 240 V AC and DC,
- Maximum voltage (Umax): 130% Un,
- Nominal current (In): 1 A,
- Maximum current (Imax): 120% In,
- Starting current: 0.05% In,
- Nominal frequency: 50 Hz±2%.

In case that meter auxiliary supply fails, the meter shall automatically switch to the VT input supply voltage and the recording of data shall not be interrupted.

Primary values for voltage and current shall be programmable using the configuration software. Immunity from electrical interference shall be as required in the appropriate IEC Standard.

Energy meters shall be three-phase, four-wire (3ph, 4w), and shall be connected in delta.

A SuperCap or lithium battery shall provide backup power for Real Time Clock (RTC) and the storage of register values and configuration data for up to one year without mains power applied.

The meters shall be provided with transformer losses compensation, Line losses compensation and energy measurement error factor applied by the user; these compensations shall be activated or de-activated depending on the user choice.

Energy meters shall be surface mounted within pertaining energy meter panels. Any accessories to mount the meter on the surface of the panel shall be provided.

Drawings indicating the dimensions of meter shall be provided either separately or included in brochures or data sheets.

3.4.2 Functionality

The following energy meter generated alarms and events shall be provided:

- Internal battery low,
- One or more phase failure (programmable threshold level – sampling frequency period to be stated),
- Overvoltage (programmable threshold level – sampling frequency to be stated),
- Meter re-programmed (incl. CT or VT ratio changed and RTC reset),
- Meter last accessed time and date (local and remote),
- Meter error (self-test),
- Voltage unbalance (programmable threshold and time delay).

Energy meters shall have a minimum of two (2) programmable relay inputs in order that externally generated alarms can be reported back to the Head-end, data collection system.

Energy meters shall have a minimum of three (3) configurable/programmable available relay outputs.

The following meter registers are required:

- Cumulative energy registers for:
  - Active energy – Import,
  - Active energy – Export,
  - Reactive energy – Import,
  - Reactive energy – Export,
- Programmable period (configurable from one minute to 60 minute), required registers for:
  - Active power – Import,
  - Active power – Export,

- Reactive power – Import,
- Reactive power – Export,

– Five Time of Use registers (Programmable by hour, day, month and season),

– Five Programmable Billing cycle registers (Wh and VArh) (Programmable by hour, day, month and season).

All registers shall be programmable to display W, kW, MW, etc.

No multiplication factors shall be allowed.

The energy meter shall have two (2) separated load profiles and each one of them have the setting for the required integration period (i.e. configurable from one minute to 60 minute) and each of them shall have the ability to store any measured value from the meter including the tariff registers.

Data registers (Load Profiles) shall have adequate capacity to store three (3) months on site data to allow for any interruptions to the automatic data Collection System, including:

– Demand log (as per above),

– Time of Use registers (Programmable by hour, day, month and season),

– Programmable Billing cycle registers (Wh and VArh),

– Voltage and current for each phase,

– Total power factor (the total power factor shall be registered in both directions export and import with sign indication).

Also, to facilitate the storage of data, meters shall be fitted with an internal power supply e.g. battery, which shall have a typical life under normal operating conditions of ten (10) years.

Start and end periods for Daylight Saving Time shall be programmable in the meter once only i.e. should not require re-programming each year (the setting shall have date and time of switching depending on customer settings and not depending only on choosing the Time Zone).

Adjustment for Daylight Saving shall occur in the meter automatically or as programmed i.e. ability to change automatically every year according to the setting of summer and winter time in the meter. Current Jordanian summertime starts on last Thursday in March at midnight, ending on last Friday in October at 01:00 am.

RTC shall not drift beyond second per month.

Energy meters should have local and remote time synchronization capability if the time drifts outside acceptable limits the synchronization will be done through the AMR server(s).

In case of energy meter auxiliary supplies failure, to ensure continuity of remote data collection, and meter operation (and the transmission of alarms and events), the energy meters shall include the facility for feed the meter from voltage transformer secondary supply using electronics within the meter.

These auxiliary supplies shall normally be taken from the 110 V DC system within each Substation, but when fail, change-over to the VT input supply voltage shall be enabled.

3.4.3 Communications

3.4.3.1 Protocols

Energy meters should use different protocols to connect for both AMR/MDM system and SCADA system to achieve that two communication ports are required. The Meters purchased will be required to integrate to the Current AMR/MDM system type ZFA-F from ITF-Froschl, and it is a condition of this tender that the bidder

ensures that this is possible and supplies the required meter driver if it is not in the current NEPCO AMR/MDM system. the preferred Protocol to connect to the AMR system is DLMS.

To connect the system with SCADA a MODBUS protocol is required to be implemented.

To achieve the above-mentioned connections the meter shall support the two communication protocols via the two required communication port simultaneously without interruption or affect the other port.

Meters may also be specified as IEC 61850 compatible for future Smart Grid integration.

3.4.3.2 Remote

The TCP/IP over Ethernet communications can be either built-in type or as an internal module and the physical connectivity shall be via RJ45 socket.

Energy meters shall have an RS-485 output to connect the meters in Multi Drop connection to connect via MODBUS for SCADA, as well as an RJ45 output from the Ethernet communications module to connect the meters to the AMR/MDM system.

3.4.3.3 Local

Local communications for meter reading and configuration purposes shall be possible via an optical port located on the front of the meter or by direct connection port.

For calibration purposes, the optical port shall also be capable of providing a suitable output pulse to calibration equipment for both active (W) and reactive (VAr) power.

All accessories to communicate with the meter shall also be supplied.

3.4.3.4 Configuration Software(s)

Meter configuration software shall be provided to enable local and full remote (via the data network without the necessity to operate any hardware for the meters locally) programming of, but not limited to, the following:

- Measurement transformer ratios
- Measurement transformer compensation
- Time and date
- Demand period duration
- Display sequence
- Time of Use registers
- Billing period

A minimum of four test points from the combined error of the current transformer and voltage transformer should be capable of being programmed in the meter.

The configuration software shall run on a Microsoft Windows environment and be compatible with a laptop computer (to be specified by the bidder – max. 15-inch screen).

The laptop quoted shall be capable of supporting multiple configuration software packages for meters of different models and manufacturers.

NEPCO will carry out all energy meter programming related to CT and VT information.

3.4.4 Labelling

Energy meters shall be marked "*The Property of National Electric Power Company*" and shall be individually serial numbered according to NEPCO approved format. Circuit names shall also be labelled on the front of the meters (NEPCO will provide these labels following Contract award).

Primary and secondary values for voltage and current shall also be displayed on the meter nameplate as well as the circuit name (these will be provided by NEPCO).

3.4.5 Security

Configuration of the energy meter shall be controlled through appropriate multiple level password protected access – to be defined by the Contractor.

Meter cover and terminal cover shall have appropriate facilities for the application of a wire (or similar) security seal.

3.4.6 Energy Meter Panels

Energy meter panel shall be constructed from 1.5 mm sheet steel and painted with primer then undercoat and finished in paint code 7035. Meter panels shall be tested to a degree of mechanical protection level of IP52.

Completed energy meter panels shall be packed to a suitable level of protection for sea freight shipping to ensure no damage occurs in transit.

A minimum of four (4) floor-fixing points shall be pre-drilled and available in the base of the cabinet. Gland plates suitable for a range of cable sizes shall be included at the base of the cabinet.

Cabinets shall be 800÷850×600×2000÷2250 (W×D×H), and rack type with transparent (shatterproof plastic) single front door hinged on the right hand side. Rear opening shall be by two (2) equally sized sheet steel doors with locking facility incorporated into the handle. Appropriate lifting eyes shall be fitted on the top of the panel and should withstand the additional weight of eight (8) energy meters.

The Contractor shall submit the General Arrangement and Wiring Diagrams of the energy meter panels for Client's approval.

The panels shall be fully wired for the number of circuits/meters and fully equipped with all necessary components and the related accessories.

All panel wiring shall be suitable for power and data signals as appropriate.

All panel wiring shall be:

- Multi-stranded,
- Colour coded according to phase colour (R, Y, B),
- Minimum cross-sectional area of 2.5mm^2 for CT, VT and auxiliary supplies circuits,
- Wires shall not be terminated without crimps.

Wires ferrules shall be supplied and approved by NEPCO for all panels.

Factory Test Certificates for all wiring checks, e.g. point-to-point and continuity tests, shall be submitted for Client's approval.

Power and data cables shall be suitably separated inside the cabinet.

All metering panels shall be fully equipped with the following:

- One 13 A power socket (UK type 3 square pins),
- One cooling fan with variable setting temperature-controlled switch,
- Internal lamp suitable for providing adequate light for working conditions, with door activated switch,
- DIN Rail and terminal blocks with appropriate isolation features and test point and earthing facilities; 10% spare terminals to be included,
- MCBs for incoming VT and power isolation with alarm contacts,
- Document/drawing storage pockets on the inside of the rear doors,
- All wiring to be enclosed in trunking with power and data cables separated,
- Engraved circuit labelling above each pair of meters (details to be provided by NEPCO),
- Open/close links for VT circuits and open/close shorting links for CT circuits,
- Earthing bar,
- Other necessary components and accessories.

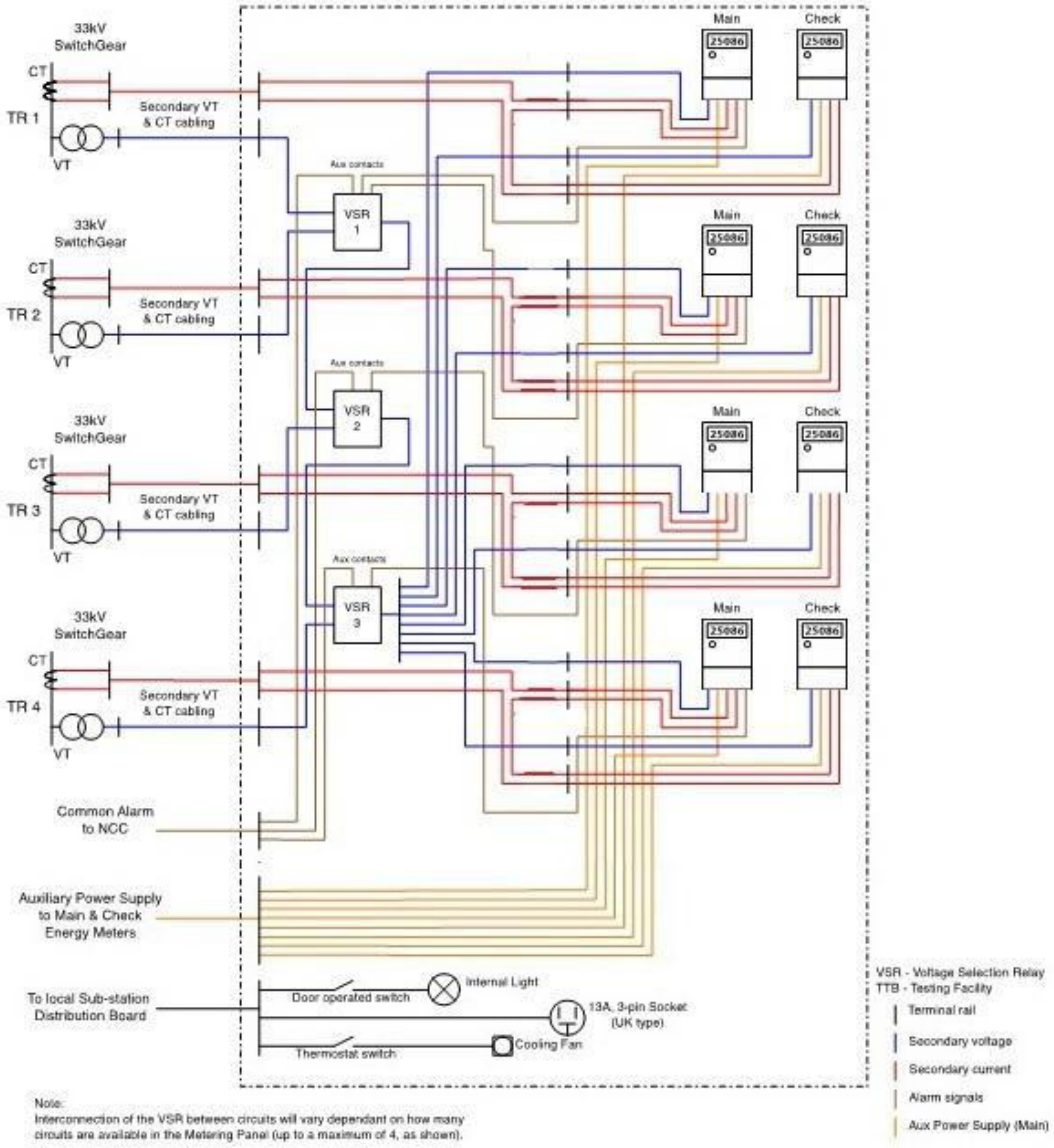
3.4.7 Voltage Selection Scheme

In order to prevent the loss of energy measurement due to the failure of a voltage transformer secondary supplying one or more measuring circuits of an energy meter, a voltage selection scheme shall be applied.

Voltage selection scheme shall be configured to switch from the designated voltage transformer secondary circuit to an alternative voltage transformer secondary (typically of a similar, adjacent circuit) should a single, or multiple phase failure occur.

Upon operation of the voltage selection scheme, an auxiliary contact shall be available which can be used as an alarm output and may be used to indicate that a failure has occurred.

Voltage Selection Scheme shall be included within the energy meter panel and shall follow the schematic diagram below.



In addition to the above, the proposed Voltage Selection Scheme shall suit the specific requirements of each substation and shall be a subject of Client's approval.

Discreet auxiliary relays shall not be a acceptable solution for providing voltage selection, and as such shall not be proposed by the Tenderer.

A maximum of four (4) circuits shall be arranged per panel.

Voltage selection relay shall function normally in the following conditions:

- Ambient temperature: -5 ºC to 50 ºC,
- Storage conditions: between 0 ºC and 30 ºC,
- Humidity: 75%.

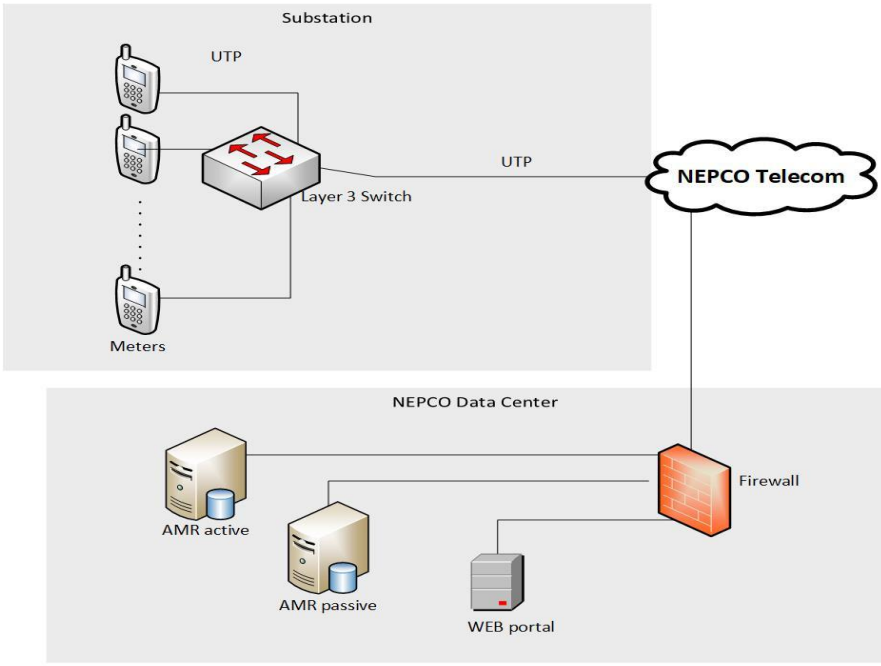
Voltage selection relay shall have the following electrical characteristics:

- Insulation class: Class I according to IEC/EN 601010-1,
- Insulation Category (Overvoltage): Category III according to IEC/EN 601010-1,
- Environment: Pollution degree 2 according to IEC/EN 601010-1,
- Product Safety:
  - 72/23/EEC,
  - EN 61010-1: 2001,
  - EN 60950-1: 2002,
- Electrical:
  - From voltage transformer secondary: 110 V AC,
  - System frequency: 50 Hz.

3.4.8 Metering System Network

The network is consisted of the following items:

- The Meter itself: each meter should have two communication ports; one of them shall be Fast Ethernet (10/100Mbps) port to be connected to NEPCO AMR network, while the other is to be connected to the billing system of the Facility. The two ports needed for data security and avoid data network interconnection and fully physical separation between the mentioned networks.
- One dedicated high performance Industrial layer 3 switch, the switch will be used to connect meters toward NEPCO AMR network.
- Cisco platforms are preferred to facilitate monitoring and health check tasks.



- In case of the industrial L3 switch is placed in a facility other than NEPCO substation, fibre cabling and termination should be done between NEPCO substation and the facility. At NEPCO side end, the termination should lead to a single RJ45 connector at telecom cabinet.

- The L3 switch should be of a form factor that is either resides in a standard 19" dedicated wall mounted network cabinet or Rail mounted in physically secured cabinet.
- Fiber termination equipment (ODFs, fiber to UTP converters, power converters, etc.) should be industrial grade equipment designed for harsh environment and should also enclosed securely within physically secured cabinet at both side of termination.
- Any fiber transceivers modules (SFPs) or fiber patch cords required to complete the physical connection up to telecom cabinet at NEPCO substation should be also provided.

3.5 33 kV Capacitor Banks

3.5.1 General

For Substation 132/33 kV as describe in schedule A: scope of work the 33 kV capacitor banks with pertaining equipment shall be supplied.

The capacitor banks, associated series (current limiting) reactors and other pertaining equipment shall be installed in a small building in the immediate vicinity of the substation control building. The capacitor banks shall be connected with pertaining 33 kV cubicles/panels with adequate 33 kV cables.

33 kV capacitor banks shall be designed in accordance with the requirements of the Standard IEC 60871 and other relevant Standards if not otherwise required in this Specification.

Capacitor banks shall be connected in ungrounded double star (Y-Y) 3-phase configuration and shall be suitable for indoor installation.

Each capacitor bank shall comprise an assembly of capacitor units which shall be internally fused. Each capacitor unit shall comprise an assembly of one or more capacitor elements in the same unit with external terminals. The containers shall be made of stainless steel or other material approved by Client.

The capacitor units shall be of the plastic film paper type, mounted on adequate insulated racks and post insulators. Poly chloride biphenyl (PCB) type impregnating fluids shall not be used. The post insulators shall be of porcelain type, unless otherwise approved by the Client. Exposed capacitor HV terminals will be protected by insulating caps.

A current transformer for unbalance detection shall be provided in the connection between the two neutrals of the double star.

The arrangement shall include all necessary racks, insulation between racks, insulation to ground, discharge and damping devices and all other necessary equipment. The capacitor bank racks shall provide accommodation for at least 20% more units than required. Means for overpressure control (diaphragm type) shall be provided for each capacitor unit as additional protection. One set of portable capacitance meter shall be provided for each substation for regular maintenance purposes.

Normal ambient temperature service conditions range for the capacitor banks shall be Class 10/D as per IEC 60871-1.

The Contractor is obliged to design capacitor bank with all associated equipment (internal fuses, discharge resistors, series reactor, surge arresters, current transformer, etc.) and to determine the rated characteristics of the equipment for the normal and transient operating conditions, as well as to coordinate them with the protection and measuring devices. The Contractor shall submit all necessary documentation (technical descriptions, drawings, data sheets, calculations, analysis, etc.) to the Client for approval. Furthermore, the Contractor shall, during design stage, submit the study for overvoltage effect on 33 kV busbars due to switching the two (2) capacitor banks (2×10 MVAr). The Contractor shall also provide harmonic study to check harmonic and resonance conditions affected by the new capacitor bank installation.

3.5.2 Internal Fuses

Internal Fuses shall be provided for protection of individual capacitor elements or groups of elements.

The fuses shall not deteriorate when the unit capacitor is subjected to the discharge test nor the currents associated with the day-to-day operation of the capacitor bank.

The Contractor shall demonstrate or provide evidence to the satisfaction of the Client that each fuse is capable of breaking the fault current produced by the failure of the capacitor element or groups of elements or complete unit capacitor to which the fuse is applied without hazard from the fuse or the unit capacitor. The Contractor shall also demonstrate or provide evidence to the satisfaction of the Client that the contamination of the impregnant is not such as to affect the reliability of the remaining sound elements.

Fuses shall be so constructed that when they operate due to a defective element(s), the blown fuse will withstand indefinitely the voltage imposed across it under working conditions.

Internal fuses shall be designed in accordance with the requirements of the Standard IEC 60871-4 and other relevant Standards if not otherwise required in this Specification.

Portable test equipment or other suitable means shall be provided to enable defective capacitors to be easily identified. The Contractor shall demonstrate the use and performance of these equipment to the Client for approval.

3.5.3 Overvoltages and Overloads

The capacitor bank shall be designed to withstand all the transient currents and voltages which may occur during operation.

In addition, the capacitor bank protection shall include equipment effective in limiting overvoltage arising from abnormal oscillatory conditions.

Each capacitor bank shall be capable of withstanding without damage, any overvoltage produced by excessive currents including inrush currents and earth fault currents for duration in which the associated protective equipment will react.

3.5.4 Discharge and Earthing Devices

Each capacitor unit shall be fitted with a discharge device to reduce the residual voltage from the peak value of the rated voltage within 10 minutes after the capacitor is disconnected from the source of supply.

The Contractor shall ensure that it is not possible to switch on capacitor banks until the voltage at the terminals is less than 10% of rated voltage.

Facilities shall be provided for short circuiting and earthing individual capacitor banks before access is allowed.

3.5.5 Duty under Fault Conditions

Capacitor units and capacitor banks shall be capable of withstanding without damage, or deterioration of fuses, an external short circuit on the terminals of the live unit capacitor or of the live capacitor bank. Due consideration shall also be given to the fact that external flashovers may occur as a result of transient overvoltages and that at the moment of the fault the capacitor unit may be charged up to a voltage considerably in excess of the normal peak voltage. The Contractor shall demonstrate the compliance with these requirements and shall submit all necessary documents which shall be a subject of Client's approval.

3.5.6 Rating and Property Plates

The rating plate of the capacitor unit and capacitor bank shall be made according to the Standard IEC 60871-1.

The rating plates shall be placed in a visible position and the inscriptions shall be clear and durable (e.g. engraved or stamped).

The data on the rating plates shall also be in accordance with Standard IEC 60871-1 and shall be submitted to the Client for approval. The text on the rating plate shall be in English language.

The capacitor bank rating plate shall be suitably mounted, if possible, at a height of 1.75 m from ground level and so attached as to be visible from outside of the capacitor bank building.

In addition to the rating plate, a property plate of design and wording approved by Client shall also be provided. Property plates may, subject to the Client approval, be provided on each rack rather than on each capacitor unit.

The rating and property plates shall be made of an approved material.

3.5.7 Racks for Capacitor Units

The racks for capacitor units shall be designed as modular units to carry all the required capacitor units, post insulators, conductors and other fittings under the loadings and factors of safety specified below and to give the specified clearances for the connections between the capacitors and associated circuits specified. The racks shall be designed to enable easy inspection and maintenance.

The insulation of the racks for capacitor units and the protection equipment shall comply with the relevant IEC recommendations for a highest system voltage of 36 kV. All safety clearances shall be according to relevant IEC recommendations

The rigidity of the complete capacitor bank shall be such that the alignment and satisfactory operation of the whole equipment shall not be affected by the loads to which the banks are subjected.

Where parts are stamped or marked for erection purposes the marking shall be legible, and where erection marks are stamped on galvanized material they shall be stamped before galvanizing and shall be clearly legible after galvanizing. All parts, bolts and nuts and all fittings shall be galvanized except racks which shall be made of aluminium.

As far as possible, bolt heads, rather than nuts shall be on the outer sides of the platform and rack parts.

The appropriate devices to facilitate the easy removal and replacement of capacitor units shall be provided. Means shall be provided to ensure that the paintwork of the capacitor containers is not damaged by the use of the removal/lifting device.

3.5.8 Series (Current Limiting) Reactors

Series (Current limiting) reactors shall be provided in series with each phase of the capacitor banks.

Series reactors shall be designed in accordance with the requirements of the Standard IEC 60076-6 and other relevant Standards if not otherwise required in this Specification.

The design and manufacture of the reactors shall be such that the noise level is a minimum and that the level of vibrations does not adversely affect any clamping or produce excessive stresses in any material.

The framework, clamping arrangements and general structure of the reactors shall be capable of withstanding any shocks to which they may be subjected during transport, installation and service. The entire assembly shall be mounted on adequate post insulators.

The materials utilised in the construction of reactors should be selected to minimise any fire risk.

Each reactor shall be fitted with bolted terminal clamps. Means for lifting reactors shall be provided.

Reactor's winding insulation and all non-metallic material used in winding stacks shall be so treated that no further shrinkage shall take place after assembly.

Winding coils shall be constructed to avoid abrasion of the insulation, (on transposed conductors), allowing for the expansion and contraction encountered during normal operation. The insulation on the conductors between turns shall be of paper type.

The windings and connections shall be braced to withstand shocks which may occur during transport or due to switching or other transient conditions during service.

Where the yoke supporting channels are adapted for taking up shrinkage in the windings, the arrangement shall be such as to throw a minimum amount of stress on any core bolt insulation.

If the winding is built up of sections or disc coils, separated by spacers, the clamping arrangements shall be such that equal pressure is applied to all columns of spacers. All such spacers shall be securely located and shall be of suitable material.

Reactor's Windings shall be designed with sufficient electrical clearance in air between adjacent layers of conductors. Where additional insulation is provided on conductors, this insulation shall be capable of withstanding temperatures of the class specified.

All metal parts other than those forming part of any electrical circuit shall be earthed in an approved manner. To facilitate this an earthing terminal, of adequate size, shall be provided near to the reactor base to which the substation earthing system shall be connected.

3.5.9 Surge Arrester & Counter

Surge Arresters shall be provided for each phase of the capacitor banks.

Surge Arresters shall be designed in accordance with the requirements of the Standards IEC 60099-4 and other relevant Standards if not otherwise required in this Specification.

The Surge Arresters shall be single-pole, metal-oxide, gapless type, suitable for use with specified 33 kV capacitor bank, complete with supporting steel structure and surge counter.

The Contractor is obligated to determine the characteristics of surge arresters for the normal and transient operating conditions and perform necessary coordination with the equipment which needs to protect. The Contractor shall submit all necessary calculations and analysis to the Client for approval.

Each single-pole surge arrester assembly shall be provided with a suitable insulating base for mounting the arrester on a steel structure.

The protective characteristics of the surge arrester shall be coordinated with the insulation levels of the equipment to be protected.

The surge arrester shall be porcelain housed type.

The surge arrester shall be of robust construction and shall be designed to facilitate handling, erection and cleaning. All joints shall be made in an approved manner so that the arrester is hermetically sealed with material which will not be deteriorated under any service conditions.

Surge arresters shall have a surge (discharge) counter along with a built-in milliammeter to monitor the leakage (internal) current of the surge arrester continuously.

The surge counter shall record the number of discharges of the surge arrester automatically on a five-digit (at least) cyclometer dial. The surge counter shall be non-reset table and capable of registering up to 5 discharges per second.

The leakage current indicator shall measure the internal current flowing through the surge arrester. The scale range shall be 0-30 mA peak/$\sqrt{2}$ (non-linear scale).

The surge counter and leakage current indicator unit shall be maintenance-free, weatherproof, sealed type.

3.5.10 Current Transformer for Unbalance Detection

A Current Transformer (CT) for unbalance detection shall be provided in the connection between the two neutrals of the double star.

The Current Transformer shall be single-phase, cast in epoxy resin.

Current transformers shall be designed in accordance with the requirements of the Standards IEC 61869-1&2 and other relevant Standards if not otherwise required in this Specification.

The active part of the current transformer shall be cast in epoxy resin, which shall ensure proper electrical insulation characteristics and mechanical protection of transformers. The epoxy resin insulation shall be done by means of a single moulding operation in order to obtain a uniform and compact insulating block, free of blow holes or other internal irregularities which might affect its characteristics and performance.

The rated extended primary current shall be 120% of the rated primary current.

The Contractor is obliged to determine the rated outputs and other characteristics of the current transformer protective cores for the normal and transient operating conditions, as well as to coordinate them with the protection devices. The Contractor shall submit all necessary calculations and analysis to the Client for approval.

The secondary terminal box shall be casted together with current transformer and protected by a detachable cover in a position easily and safely accessible for inspection and maintenance. Design of the terminal box shall prevent any possibility of accidental opening of the secondary circuits.

Each current transformer secondary winding circuit shall be earthed at only one point. Wherever possible the connection to earth shall be at S3 terminals.

3.5.11 Interlocking and Access

For the 33 kV capacitor banks, which are in scope of supply, the following interlocking shall be applied:

- The transformer 132 kV circuit breaker cannot be closed unless the associated capacitor bank circuit breakers are open,
- The capacitor bank circuit breakers cannot be closed unless the transformer 132 kV and 33 kV circuit breakers are closed,
- The capacitor bank circuit breakers must be opened prior to isolating the associated main transformer from the 132 kV and 33 kV sides (operational procedure).
- The capacitor bank circuit breakers cannot be closed unless the necessary time delay to discharge the associated capacitor bank after the last opening of the circuit breaker has elapsed.

The access doors in the capacitor bank building shall be interlocked in a manner such that access cannot be obtained unless the bank is disconnected from the source of supply and the associated earthing switch has been closed. Also, it shall not be able to open the earthing switch unless the associated access doors in the capacitor bank building are closed. All electrical interlocks shall function so as to interrupt the operating supply. An approved system of interlocks shall be provided which shall cover the emergency hand operation of apparatus which is normally power operated. Failure of supply connections to any electrical interlock shall not produce or permit faulty operation.

Where the specified clearances are not obtainable with an approved arrangement of the equipment, earthed screen enclosures or partitions shall be provided to prevent approach to any live part. The screens and partitions necessary for each equipment shall be included in this Contract.

In addition to the interlocking equipment, provision shall be made for accommodating padlocks, supplied under this Contract, on all access doors, earth switches, etc.

4. INSPECTION AND TESTS

4.1. General

In addition to the general requirements for inspection and tests stated within General Technical Specifications, the following shall also be applied:

- Tests shall be performed to determine whether the materials and the equipment comply with the technical requirements. All tests shall be performed in the conditions which, as much as possible, correspond to the operating conditions,
- The Contractor shall submit to the Client for approval, the Test Program for all the necessary tests. For each performed test, the Contractor shall prepare the appropriate Test Report and shall submit it to the Client for approval,
- All tests on the equipment, both at the Manufacturer's factory and after completion of installation at the Site, shall be performed in accordance with IEC, BS, and IEEE Standards, unless otherwise agreed with the Client. If IEC, BS, and IEEE Standards are not available for tests, the scope, Standard and procedures to be applied shall be specified by the Contractor and approved by the Client,
- All additional tests, except those specified further below, which might be necessary for confirmation of the equipment guaranteed characteristics, shall be performed at the Clients' request and with no additional cost to the Client,
- Appropriate standard instruments and other measuring equipment, as well as technical personnel, necessary for performance of the Factory Tests shall be provided by the Contractor,
- Appropriate measuring equipment, as well as technical personnel, necessary for performance of the Site Tests and Commissioning of the equipment shall be provided by the Client, while the Contractor shall provide technical Supervision during execution of Site Tests and Commissioning,
- The tests shall not diminish characteristics and reliability of the tested equipment or shorten its lifetime,
- The Detailed Program of the Factory Tests shall be submitted minimum 28 calendar days before commencement of the tests. These tests shall comprise minimum the tests specified in Clause 4.2 of these Particular Technical Specifications. These Detailed Programs shall also comprise the procedures and all details of the procedures and charts of measurements, conditions, and implementation of the testing procedures, as well as the sequence of equipment preparation, the operating procedures to be applied, etc.,
- The Detailed Program of the Factory Tests shall be approved by the Client 21 calendar days after the documents have been submitted,
- The details of the tests are given further below.

4.2. Factory Tests

4.2.1. General

Factory tests shall be performed in the presence of the Client; however, some tests may be performed in the Client's absence, with his prior consent.

Factory tests shall include tests during manufacture and Factory Acceptance Tests (FAT).

Tests during manufacture shall include routine tests for each type of equipment to be installed.

After satisfactory completion of the witnessed tests at the Factory, the Contractor shall submit Shipping Release request for Client.

No item of equipment shall be dispatched to Site until the Client has given his approval and issued the relevant Shipping Release.

4.2.2. Type Tests Certificates

4.2.2.1 General

It is required that all offered equipment will have type test certificates. Type Tests Certificates shall be submitted for the equipment same as required in ITT.

All testing laboratories shall be accredited according to ISO/IEC 17025 by ILAC (The International Laboratory Accreditation Cooperation).

The following Clauses define the minimum requirement for type test certificates.

4.2.2.2 33 kV Switchgears

At least the following type test certificates for 33 kV switchgears (according to IEC 62271-200) shall be provided:

- Dielectric tests,
- Measurement of the resistance of circuits,
- Temperature-rise tests,
- Short-time withstand current and peak withstand current tests,
- Verification of the protection,
- Electromagnetic compatibility tests (EMC),
- Tests on auxiliary and control circuits,
- Verification of making and breaking capacities,
- Mechanical operation tests,
- Tests to verify the protection of persons against dangerous electrical effects,
- Internal arc test.

It is also necessary to provide type test certificates for the equipment which shall be installed within the 33 kV switchgears:

- For the circuit breakers, in accordance with the Standard IEC 62271-100,
- For the earthing switches, in accordance with the Standard IEC 62271-102,

- For the current transformers, in accordance with the Standard IEC 61869-1&2,
- For the voltage transformers, in accordance with the Standard IEC 61869-1&3.

4.2.2.3 Protection Equipment

Type test certificates shall be provided for each type of protection system. Each set of test records shall include a full statement of the performance claims, e.g. performance under reference conditions, effect of influencing the quantities, steady state and dynamic stability for unit protection schemes, current and voltage transformer requirements, etc and full details of tests performed on representative samples of production equipment to demonstrate that the performance claims have been met.

For circulating current protective schemes using high impedance relays, calculation of the predicted performance will be accepted in lieu of type testing of each individual scheme. Type test results must, however, be available for inspection by the Client to show that heavy current conjunctive tests have been performed on a representative scheme to prove the stability and operating time performance.

4.2.2.4 33 kV Capacitor Banks

At least the following type test certificates for 33 kV capacitor banks (according to IEC 60871-1) shall be provided:

- Thermal stability test,
- Measurement of the tangent of the loss angle (*tan*δ) of the capacitor at elevated temperature,
- AC voltage test between terminals and container,
- Lightning impulse voltage test between terminals and container,
- Overvoltage test,
- Short-circuit discharge test,
- Disconnecting test on internal fuses.

4.2.3. Routine Tests

4.2.3.1 General

Routine tests shall be performed at the Manufacturer's factory and in the Client's presence, on each part of the equipment foreseen for delivery, for the purpose of detecting failures in the material or in the structure. Tests shall be performed in accordance with the latest edition of the relevant IEC, BS, and IEEE Standards, unless specified otherwise. The test results shall be submitted to the Client for consideration, immediately after completion of the tests.

4.2.3.2 33 kV Switchgears

At least, but not limited to, the following routine tests for 33 kV switchgears (according to IEC 62271-200) shall be performed:

- Dielectric test on the main circuit,
- Tests on auxiliary and control circuits,
- Measurement of the resistance of the main circuit,
- Design and visual checks,
- Partial discharge measurement,

- Mechanical operation tests,
- Tests of auxiliary electrical devices.

It is also necessary to perform the routine tests for the equipment which shall be installed within the 33 kV switchgears:

- For the circuit breakers, in accordance with the Standard IEC 62271-100,
- For the earthing switches, in accordance with the Standard IEC 62271-102,
- For the current transformers, in accordance with the Standard IEC 61869-1&2,
- For the voltage transformers, in accordance with the Standard IEC 61869-1&3.

4.2.3.3 Control and Indicating Panels, Instruments and Secondary Wiring

All panels and instruments shall comply with the tests specified in the appropriate Standards.

The wiring on each panel, cubicle, rack and each removable panel or plate of apparatus shall be subjected for one minute to an alternating voltage equal to the test pressure specified for the apparatus to which it is connected. This test shall take place after the complete assembly of the apparatus and wiring on or in the panels, cubicles and racks.

All wiring and apparatus which is, or may become, connected to voltage sources other than the supply for the very low voltage (50 volts and below) apparatus shall be subjected for one minute to an alternating test pressure of 2 000 volts rms to the frame of the panels on which they are accommodated, immediately after which the insulation measured at 6 500 volts dc shall not be less than 20 megohms. Included in these requirements is apparatus and wiring which become connected to voltage or current transformers.

The windings and electrical connections of indicating and recording meters shall be subjected for one minute to a test voltage of 2 000 volts rms to the case or any other metal which is not intended to be insulated from the case when the instrument or meter is in use.

One typical mimic diagram panel shall be erected as in service and the indicating devices operated to the satisfaction of the Client.

4.2.3.4 Protection Equipment

All relays shall be subjected to routine tests at the Manufacturer's factory to confirm that they comply with the required performance and design limits.

For measuring relays (i.e. relays which have a defined setting of the input and/or characteristic quantity subjected to accuracy requirements, e.g. current, time, etc.) these routine tests shall include as a minimum the following:

- Measurement of the assigned error(s) under reference conditions, i.e. measuring accuracy and operating time characteristics,
- Measurement of the resetting ratios,
- Dielectric tests according to IEC 60255-27, the test voltage being 2 kV rms. All normally open output contacts of all relays shall withstand a test voltage of 1 kV rms.

For all-or-nothing relays, the routine tests shall include a check of relay operation and resetting, together with the dielectric tests described above.

Unless otherwise agreed with the Client, all unit protection schemes using either biased differential, current balance or voltage balance principles shall be subjected to heavy current conjunctive tests using the actual current transformer windings which will be used in service. Tests shall be made to prove operating sensitivity, time

of operation and to demonstrate stability of the protection under the worst transient external fault conditions. Tests will only be waived if the manufacturer is able to produce type test results for an identical scheme. In this case it will be sufficient to prove that individual component characteristics are identical, e.g. current transformers are of the same design, have the same magnetisation characteristics, knee-point voltage and secondary resistance.

For protection schemes including distance protection, phase comparison protection, auto reclosing and automatic switching sequence schemes, etc. routine tests shall be performed on each complete scheme to ensure that all possible operational sequences and features are fully functional. Where necessary, this shall be done using simulation of any ancillary equipment normally used in conjunction with the scheme, e.g. circuit breakers. These routine tests will be performed in addition to the tests normally applied to individual elements of the scheme and details of the proposed test programme shall be submitted to the Client for approval not less than one month before they are to be performed.

If such routine tests are not practicable due to the complexity of the scheme, a scheme type test will be accepted on representative production equipment. The test shall be performed so as to simulate, as nearly as possible, the conditions which will be experienced in service and details of the proposed test programme shall be submitted to the Client for approval not less than one month before they are performed. In those cases where correct operation of the scheme is dependent on measured quantities associated with primary system equipment (e.g. circuit breaker gas pressure), such quantities shall be measured directly during the tests.

Each circulating current protection scheme designed to use high impedance relays shall fulfil the following routine testing requirements:

- Each current transformer, which must be of the low reactance type, shall be individually tested for turns ratio, secondary winding resistance and excitation characteristic up to a secondary voltage equal to 120% of the "knee-point" voltage,
- The VA consumption at operation of current operated relays shall be measured and shall not exceed the maximum value declared by the Manufacturer,
- The operating current of voltage relays shall be measured and shall not exceed the maximum value declared by the Manufacturer.

4.2.3.5 33 kV Capacitor Banks

At least the following routine tests for 33 kV capacitor banks (according to IEC 60871-1) shall be performed:

- Capacitance measurement,
- Measurement of the tangent of the loss angle (*tan*δ) of the capacitor,
- Voltage test between terminals,
- AC voltage test between terminals and container,
- Test of internal discharge device,
- Sealing test,
- Discharge test on internal fuses.

5. Documentation

5.1. Documentation to be Submitted with the Tender

Together with the Tender, completed with pertaining Schedule of Technical Data duly filled-in, the Tenderer shall submit the following documentation/information:

- Single Line Diagrams of the 33 kV Switchgears,
- Single Line Diagrams of the 33 kV Capacitor Banks,
- General arrangement drawings, cross-section drawings of the switchgear/cubicles, showing details of all associated equipment and accessories, their overall and lifting dimensions, weights of the complete cubicles and their main components,
- General arrangement drawings of Control and Protection panels,
- General arrangement drawings of 33 kV capacitor banks, showing details of all associated equipment and accessories, their overall and lifting dimensions, weights of the main components,
- Clear evidence (analysis, certificates, etc.) that the offered SF6 type circuit breaker is suitable for capacitor bank application,
- Protection diagrams (block schemes),
- Detailed descriptions with characteristics of the proposed 33 kV switchgears and associated equipment (catalogues, descriptive literature, manufacturing Specifications),
- Reference lists of the proposed equipment,
- Type Test Certificates (according to ITT requirements)

5.2. The Documentation to be Submitted after Contract Commencement Date

Within the one (1) month upon Contract Commencement Date, the Contractor shall submit the following documentation as a minimum to Client for review and approval:

- Detailed Time Schedule for execution of Works under this Contract (Program of Works), comprising all activities from the design to taking-over,
- List of complete documentation to be submitted under this Contract,
- List of equipment/material samples and models to be submitted under this Contract,

Within the two (2) months upon Contract Commencement Date, the Contractor shall submit the following documentation as a minimum to Client for review and approval:

- Single line diagram of the 33 kV switchgears,
- Single line diagram of the 33 kV capacitor banks,
- Outline drawings of the complete equipment to be supplied under this Contract,
- Foundation drawings with all necessary details for fixation for the equipment to be supplied under this Contract,
- Detailed technical description of the complete equipment to be supplied under this Contract,
- Detailed protection diagrams including tripping logic/matrix,

- Details (drawings, information, data, etc.) necessary for connection with the equipment which shall be supplied under Contracts,
- Requirements for civil design related to equipment that shall be procured, such as ceiling heights, front, rear & lateral clearances for cubicles and panels, cable trenches, cable entry position, etc.,
- Necessary calculations & analysis, such as:
  - Calculation/Verification of 33 kV switchgear equipment characteristics,
  - Calculations necessary to prove the compatibility of instrument transformers to the connected control, protection and metering equipment,
  - Calculations/Dimensioning of 33 kV capacitor bank equipment and connecting material,
  - Study for overvoltage effect on 33 kV busbars due to switching the two (2) capacitor banks (2×10 MVAr),
  - Study to check harmonic and resonance conditions affected by the new capacitor bank installation,
  - All other calculations, necessary for dimensioning/sizing of the 33 kV switchgears & associated equipment.
- All other data that Contractor considers as necessary for submission to the Client.

Within the five (5) months upon Contract Commencement Date, the Contractor shall submit the following documentation as a minimum to Client for review and approval:

- Detailed front view and cross section drawings of the equipment supplied under this Contract, including all dimensions, weights and transport details,
- Detailed layout & cross section drawings of the substations showing equipment and systems which shall be procured in (33 kV switchgears, 33 kV control, protection & metering equipment, 33 kV capacitor banks), including the existing equipment and systems (for extension and replacement projects),
- Detailed electrical schematic diagrams, including block-diagrams, single line diagrams, circuit diagrams, I/O signal list, wiring diagrams and connection diagrams,
- Cable list with defined interconnections of the equipment supplied under this Contract, with connections between the equipment supplied under this Contract and the equipment to be supplied under Contracts and existing equipment as well,
- Protection calculations & settings,
- Detailed Program of the Factory Tests,
- Detailed Program of the recommended Site Tests,
- Instructions for Equipment Installation (review only),
- Operation and Maintenance Manuals (review only),
- Program of Training for the installation, operation, maintenance and testing of the equipment to be delivered,
- All other data that Contractor considers as necessary for submission to the Client.
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At least one (1) month prior to shipment, the Contractor shall submit the following documentation as a minimum to Client for review and approval:

- Signed approved Factory Test Reports,
- Clear evidence that all comments during FATs have been corrected,
- Detailed packing lists, transport program and insurance documentation,
- Instructions for loading, unloading, handling and particular safety measures to the applied during storage (review only