NEPAL ELECTRICITY AUTHORITY
(An Undertaking of Government of Nepal)
Project Management Directorate

MARSYANGDI CORRIDOR 220 KV TRANSMISSION LINE PROJECT

BIDDING DOCUMENT
FOR
Procurement of Plant
Design, Supply, Installation and Commissioning
Of Manang-Khudi-Udipur 220 kV Transmission Line and Associated Substations at Khudi & Manang

Single-Stage, Two-Envelope
Bidding Procedure

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(Part 2 of 3)  

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CHAPTER 15: CONTROL, RELAY & PROTECTION PANELS

1. TYPE OF PANELS

1.1 Simplex Panel

Simplex panel shall consist of a vertical front panel with equipment mounted thereon and having wiring access from rear for control panels and front for relay/protection panels. In case of panel having width more than 800mm, double leaf-doors shall be provided. Doors shall have handles with either built-in locking facility or will be provided with pad-lock.

1.2 Duplex Panel

Duplex panel shall be walk-in tunnel type comprising two vertical front and rear panel sections connected back-on-back by formed sheet steel roof tie members and a central corridor in between. The corridor shall facilitate access to internal wiring and external cable connections. In case of number of duplex panels located in a row side by side, the central corridor shall be aligned to form a continuous passage. Both ends of the corridor shall be provided with double leaf doors with lift off hinges. Doors shall have handles either with built-in locking facility or shall be provided with pad-locks. Separate cable entries shall be provided for the front and rear panels. However, inter-connections between front and back panels shall be by means of inter panel wiring at the top of the panel.

2. CONSTRUCTIONAL FEATURES

2.1. Control and Relay Board shall be of panels of simplex or duplex type design as indicated in bill of quantity. It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes be properly accommodated in the panels without congestion and if necessary, either add more number of panels or provide panels with larger dimensions. No price increase at a later date on this account shall be allowed. However, the width of panels that are being offered to be placed in existing switchyard control rooms, should be in conformity with the space availability in the control room.

2.2. Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IEC 60529 (Part-1).

2.3. Panels shall be free standing, floor mounting type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

2.4. All doors, removable covers of panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh

2.5. Design, materials selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent from outside, with all exterior surfaces tune and smooth.

2.6. Panels shall have base frame with smooth bearing surface, which shall be fixed on the embedded foundation channels/insert plates. Anti vibration strips made of
shock absorbing materials that shall be supplied by the contractor, which shall be placed between panel & base frame.

2.7. Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.

2.8. Relay/protection panels of modern modular construction would also be acceptable.

3. **MOUNTING**

3.1. All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush.

3.2. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

3.3. The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer’s drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

3.4. The centre lines of switches, push buttons and indicating lamps shall not be less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall not be less than 450mm from the bottom of the panel.

3.5. The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.

3.6. No equipment shall be mounted on the doors.

3.7. At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

4. **PANEL INTERNAL WIRING**

4.1. Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be carried out internally.

4.2. All wiring shall be carried out with 650V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows:

- All circuits except current transformer circuits and voltage transfer circuits meant for energy metering - one 1.5mm sq. per lead.
- All current transformer circuits - one 2.5 sq.mm per lead.
- Voltage transformer circuit (for energy meters): Two 2.5 mm sq. per lead.
4.3. All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.

4.4. Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panels running throughout the entire length of the panels.

4.5. Wire termination shall be made with solderless crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.

4.6. Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires.

4.7. Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

5. TERMINAL BLOCKS

5.1. All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amps. continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

5.2. Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.

5.3. At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

5.4. Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side

- All CT & PT circuits: minimum of two of 2.5mm Sq. copper.
- AC/DC Power Supply Circuits: One of 6mm Sq. Aluminium.
- All other circuits: minimum of one of 2.5mm Sq. Copper.

5.5. There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. Also the clearance between two rows of terminal blocks edges shall be minimum of 150mm.

5.6. Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallel and close proximity along each side of the wiring-duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the external cable connections. All adjacent terminal blocks shall also share this field wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible
termination without causing strain on terminals.

5.7. The number and sizes of the Owner's multi core incoming external cables will be furnished to the Contractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included in the scope of supply.

6. **PAINTING**

The painting shall be carried out as detailed in Chapter 2–GTR.

7. **MIMIC DIAGRAM**

7.1. Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.

7.2. Mimic diagram shall be made preferably of anodised aluminium or plastic of approved fast colour material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be 10mm for bus bars and 7mm for other connections. Painted overlaid mimic is also acceptable.

7.3. Mimic bus colour will be decided during detailed Engineering.

7.4. When semaphore indicators are used for equipment position, they shall be so mounted in the mimic that the equipment in close position shall complete the continuity of mimic.

7.5. Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition.

8. **NAME PLATES AND MARKINGS**

8.1. All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

8.2. All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

8.3. Each instrument and meter shall be prominently marked with the quantity measured e.g. KV, A, MW, etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

8.4. Name Plates shall be made of non-rusting metal or 3 ply lamicoid. Name plates shall be black with white engraving lettering.

8.5. Each switch shall bear clear inscription identifying its function e.g. 'BREAKER' '52A', "SYNCHRONISING" etc. Similar inscription shall also be provided on each device whose function is not other-wise identified. If any switch device does not bear this inscription separate name plate giving its function shall be provided for it. Switch shall also have clear inscription for each position indication e.g. "Trip-Neutral-Close", "ON-OFF", "R-Y-B-OFF" etc.

8.6. All the panels shall be provided with name plate mounted inside the panel bearing LOA No & Date, Name of the Substation & feeder and reference drawing number.

9. **MISCELLANEOUS ACCESSORIES**
9.1.  **Plug Point**: 230V, Single phase 50Hz. AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.

9.2.  **Interior Lighting**: Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

9.3.  **Switches and Fuses**: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. Selection of the main and sub-circuit Fuses rating shall be such as to ensure selective clearance of sub-circuit faults. Voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to IS: 13703 mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.

9.4.  **Space Heater**: Each panel shall be provided with a thermostatically connected space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

10.  **EARTHING**

10.1.  All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference from earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq.mm copper with threaded holes at a gap of 50 mm with provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractor. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

10.2.  Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Contractor.

10.3.  All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.

10.4.  Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. However, looping of earth connections between equipment to provide alternative paths to earth bus shall be provided.

10.5.  VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.

10.6.  An electrostatic discharge arrangement shall be provided in each panel so as to discharge human body before he handles the equipments inside the panels.

11.  **INDICATING INSTRUMENTS & TRANSDUCERS FOR CONTROL PANEL:**
All instruments, meters and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All megawatt, megavar, Bus voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The supplier shall submit calibration certificates at the time of delivery. However no separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronising equipment.

11.1. Indicating Instruments

11.1.1. Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.

11.1.2. Instruments shall have 4-digit display; display height being not less than 25 mm

11.1.3. Instrument shall confirm to relevant IEC and shall have an accuracy class of 1.5 or better. Watt and Var meters shall have an indication of (+) and (-) to indicate EXPORT and IMPORT respectively.

11.1.4. Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of 5 and 4 digits respectively, with display size, not less than 25mm (height).

11.2. Transducers

11.2.1. Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform to IEC:688-1

11.2.2. The transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.

11.2.3. The input to the transducers will be from sub-station current & potential transformers. The output shall be in milli ampere D.C. proportional to the input & it shall be possible to feed the output current directly to the telemetry terminal or indicating instruments.

11.2.4. The transducer characteristic shall be linear throughout the measuring range.

11.2.5. The transducer output shall be load independent.

11.2.6. The input & output of the transducer shall be galvanically isolated.

11.2.7. Each transducer shall be housed in a separate compact case and have suitable terminals for inputs & outputs.

11.2.8. The transducers shall be suitably protected against transient high peaks of voltage & current.

11.2.9. The transducer shall withstand indefinitely without damage and work satisfactorily at 120% of the rated voltage and 120% of the rated input current as applicable.

11.2.10. All the transducers shall have an output of 4-20 mA.

11.2.11. The response time of the transducers shall be less than 1 second.

11.2.12. The accuracy class of transducers shall be 1.0 or better for voltage/current transducer, 0.5 or better for watt/VAR transducer and 0.2 or better for frequency transducer.
11.2.13. The transducers shall have a low AC ripple on output less than 1%.
11.2.14. The transducer shall have dual output.

12. ANNUNCIATION SYSTEM for Control Panel

12.1. Alarm annunciation system shall be provided in the control board by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operation of some protective devices. The annunciation equipment shall be suitable for operation on the voltages specified in this specification.

12.2. The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the control panels.

12.3. The annunciation facia shall be provided with translucent plastic window for alarm point with approximate size of 35mm x 50mm. The facia plates shall be engraved in black lettering with respective inscriptions. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall not be less than 5 mm.

12.4. Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The transparency of cover plates and wattage of the lamps provided in the facia windows shall be adequate to ensure clear visibility of the inscriptions in the control room having high illumination intensity (350 Lux), from the location of the operator's desk.

12.5. All Trip facia shall have red colour and all Non-trip facia shall have white colour.

12.6. The audible alarm shall be provided by Buzzer/ Hooter /Bell having different sounds and shall be used as follows.

| Hooter | Alarm Annunciation |
| Bell | Annunciation DC failure |
| Buzzer | AC supply failure |

12.7. Sequence of operation of the annunciator shall be as follows:

<table>
<thead>
<tr>
<th>Sl. NO.</th>
<th>Alarm Condition</th>
<th>Fault Contact</th>
<th>Visual Annunciation</th>
<th>Audible Annunciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Normal</td>
<td>Open</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>2.</td>
<td>Abnormal</td>
<td>Close</td>
<td>Flashing</td>
<td>ON</td>
</tr>
<tr>
<td>3.</td>
<td>Accept Push Button Pressed</td>
<td>Close</td>
<td>Steady On</td>
<td>OFF</td>
</tr>
<tr>
<td>4.</td>
<td>Reset Push Button Pressed</td>
<td>Open</td>
<td>Steady On</td>
<td>OFF</td>
</tr>
<tr>
<td>5.</td>
<td>Lamp Test Push Button Pressed</td>
<td>Open</td>
<td>Steady On</td>
<td>OFF</td>
</tr>
</tbody>
</table>

12.8. Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 230 Volts AC supply. On failure of the DC to the annunciation system for more than 2 or 3 seconds (adjustable setting), a bell shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone but the facia window
shall remain steadily lighted till the supply to annunciation system is restored.

12.9. A separate voltage check relay shall be provided to monitor the failure of supply (230V AC) to the scheme mentioned in Clause above. If the failure of supply exists for more than 2 to 3 seconds, this relay shall initiate visual and audible annunciation. Visual and audible annunciation for the failure of AC supply to the annunciation system shall be provided and this annunciation shall operate on Annunciation DC and buzzer shall sound.

12.10. The annunciation system described above shall meet the following additional requirements:

a) The annunciation system shall be capable of catering to at least 20 simultaneous signals at a time.

b) One set of the following push buttons shall be provided on each control panel:
   - Reset push button for annunciation system
   - Accept push button for annunciation system
   - Lamp test push button for testing the facia windows

c) One set of the following items shall be provided common for all the control panel (not applicable for extension of substation):
   - Flasher relay for annunciation system
   - Push button for Flasher test
   - Three Push buttons for test of all audible alarm systems

d) These testing circuits shall be so connected that while testing is being done, it shall not prevent the registering of any new annunciation that may land during the test.

e) The annunciation shall be repetitive type and shall be capable of registering the fleeting signal. Minimum duration of the fleeting signal registered by the system shall be 15 milli seconds.

f) In case of static annunciator scheme, special precaution shall be taken to ensure that spurious alarm condition does not appear due to influence of external electromagnetic/ electrostatic interference on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels and the static annunciator shall meet the high voltage susceptibility test, impulse voltage withstand test, high frequency disturbance test – class III and fast transient disturbance test – level III as per IEC 60255.

12.11. The annunciation system to be supplied for existing sub-stations shall be engineered as an extension to the existing scheme.

13. SWITCHES

13.1. Control and instrument switches shall be rotary operated type with escutcheon plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out.

13.2. The selection of operating handles for the different types of switches shall be as follows:

Breaker, Isolator control switches: Pistol grip, black
Synchronising switches: Oval, Black, Keyed handle (one
common removable handle for a group of switches or locking facility having common key)

synchronising Selector switches : Oval or knob, black
Instrument switches : Round, knurled, black
Protection Transfer switch : Pistol grip, lockable and black.

13.3. The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip positions to "after close" and "after trip" positions respectively.

13.4. Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. Voltmeter transfer switches for AC shall be suitable for reading all line-to-line and line-to-neutral voltages for non-effectively earthed systems and for reading all line to line voltages for effectively earthed systems.

13.5. Synchronising switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the OFF position and it shall be co-ordinated to fit into all the synchronising switches. These switches shall be arranged to connect the synchronising equipment when turned to the 'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.

13.6. Lockable type of switches which can be locked in particular positions shall be provided when specified. The key locks shall be fitted on the operating handles.

13.7. The contacts of all switches shall preferably open and close with snap action to minimise arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts.

13.8. The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.

13.9. The contact rating of the switches shall be as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Contact Rating in Amps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>220V DC</td>
</tr>
<tr>
<td>Make and carry</td>
<td></td>
</tr>
<tr>
<td>Continuously</td>
<td>10</td>
</tr>
<tr>
<td>Make and carry for 0.5 sec.</td>
<td>30</td>
</tr>
<tr>
<td>Break for Resistive load</td>
<td>3</td>
</tr>
<tr>
<td>Break for Inductive load with L/R = 40m sec.</td>
<td>0.2</td>
</tr>
</tbody>
</table>
14. **INDICATING LAMPS**

14.1. Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights coloured red, green, amber, clear white or blue as specified. The lamp cover shall be preferably of screwed type, unbreakable and moulded from heat resisting material.

14.2. The lamps shall be provided with suitable resistors.

14.3. Lamps and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if required for replacing the bulbs and lenses shall also be included in the scope of the supply.

14.4. The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis.

15. **POSITION INDICATORS (if Applicable)**

15.1. Position indicators of "SEMAPHORE" type shall be provided when specified as part of the mimic diagrams on panels for indicating the position of circuit breakers, isolating/earthing switches etc. The indicator shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connection from the rear. Their strips shall be of the same colour as the associated mimic.

15.2. Position indicator shall be suitable for DC Voltage as specified. When the supervised object is in the closed position, the pointer of the indicator shall take up a position in line with the mimic bus bars, and at right angles to them when the object is in the open position. When the supply failure to the indicator occurs, the pointer shall take up an intermediate position to indicate the supply failure.

15.3. The rating of the indicator shall not exceed 2.5 W.

15.4. The position indicators shall withstand 120% of rated voltage on a continuous basis.

16. **SYNCHRONISING EQUIPMENT**

16.1. For sub-station equipped with sub-station Automation system, the requirement of synchronisation is specified in chapter Sub-station Automation System and the same shall prevail. For other sub-station which is not equipped with Sub-sub-station automation system following shall be applicable as per requirement.

16.1. The synchronising instruments shall be mounted either on a synchronising trolley or on a synchronising panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronising panel shall not be less than 144 X 144 sq.mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided.

16.1. Synchronising check relay with necessary ancillary equipment’s shall be provided which shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the
two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have an adjustable time setting range of 0.5-20 seconds. A guard relay shall be provided to prevent the closing attempt by means of synchronising check relay when control switch is kept in closed position long before the two systems are in synchronism.

16.1. The synchronising panel shall be draw out and swing type which can be swivelled in left and right direction. The synchronising panel shall be placed along with control panels and the number of synchronising panel shall be as indicated in BPS. The incoming and running bus wires of VT secondary shall be connected and run as bus wires in the control panels and will be extended to synchronising panel for synchronisation of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronising mode at a time.

16.1. Alternatively, the trolley shall be of mobile type with four rubber-padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

16.1. At existing sub-stations, the synchronising scheme shall be engineered to be compatible with the existing synchronising scheme and synchronising socket/switch on the panel. In substations, where synchronising panels are available, the bidder shall carry out the shifting of the above panels, if required, to facilitate the extension of control panel placement.

17. RELAYS

17.1. All relays shall conform to the requirements of IS: 3231/IEC-60255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

17.2. All protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. Further, the test levels of EMI as indicated in IEC 61850 shall be applicable to these relays.

17.3. All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

17.4. All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

17.5. The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete
protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme; contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

17.6. Timers shall be of solid state type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.

17.7. No control relay, which shall trip the power circuit breaker when the relay is de-energised, shall be employed in the circuits.

17.8. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

17.9. Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

(a) The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.

(b) Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.

(c) Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.

(d) Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s), but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, reclosing function etc.), and the alarm output signals.

(e) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).

(f) For the current seal-in method, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset and the seal-in method shall now revert to the fixed time duration method. For this seal-in method, the seal-in shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.

(g) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).

17.10. The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.
17.11. Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the OWNER.

17.12. All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue

17.13. For numerical relays, the scope shall include the following:
   a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.
   b) The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC-61850 protocol.
   c) In case of line protection and transformer/reactor protection, the features like fault recorder and event logging function as available including available as optional feature in these relays shall be supplied and activated at no extra cost to the owner. Also necessary software/ hardware for automatic uploading to station HMI/DR work station (as applicable) shall be supplied. It is to be clearly understood that these shall be in addition to Fault recorder function as specified at clause no. 28.

18. TRANSMISSION LINE PROTECTION

18.1. All relays shall be suitable for series compensated line.

18.2. The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines. The general concept is to have two main protections having equal performance requirement specially in respect of time as called Main-I and Main-II for 220KV transmission lines and Main and back up protection for 132 KV transmission lines.

18.3. The Transmission system for which the line protection equipment are required is indicated in Chapter 1 – General Technical Specification (GTS)

18.4. The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current of CT secondary. The starting & measuring relays characteristics should be satisfactory under these extremely varying conditions.

18.5. The protective relays shall be suitable for use with capacitor voltage transformers having non-electronic damping and transient response as per IEC.

18.6. Fault Recorder, Distance to fault Locator and Over voltage relay (stage -1/2) functions if offered as an integral part of line protection relays, shall be acceptable provided these meet the technical requirements as specified in the respective clauses.

18.7. Auto reclose relay function if offered as an integral part of line distance protection relay, shall be acceptable for 132 KV lines only provided the auto reclose relay feature meets the technical requirements as specified in the respective clause.

18.8. The following protections shall be provided for each of the Transmission lines:

For 220KV

Main-I: Numerical distance protection scheme

Main-II: Numerical distance protection scheme of a make different from that of
Main –I

**For 132KV**

**Main:** Numerical distance protection scheme  
**Back up:** Directional Over Current and Earth fault Protection

The detailed description of line protections is given here under.

18.9. **Main-I and Main-II Distance Protection scheme:**

(a) shall have continuous self monitoring and diagnostic feature  
(b) shall be non-switched type with separate measurements for all phase to phase and phase to ground faults  
(c) shall have stepped time-distance characteristics and three independent zones (zone 1, zone-2 and zone-3)  
(d) shall have mho or quadrilateral or other suitably shaped characteristics for zone-1, zone-2 and zone-3  
(e) shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

   **(i)** for **220 KV lines:**

<table>
<thead>
<tr>
<th>For Source to Impedance ratio:</th>
<th>4</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relay setting (Ohms)</td>
<td>(10 or 20) and 2</td>
<td>2</td>
</tr>
<tr>
<td>Fault Locations</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>(as % of relay setting)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fault resistance (Ohms)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maximum operating time (Milliseconds)</td>
<td>40 for all faults</td>
<td>45 for 3 ph. Faults &amp; 60 for all other faults</td>
</tr>
</tbody>
</table>

   **(ii)** for **132 KV lines:**

   A relaxation of 5 ms in above timings is allowed for 132 KV lines.

(f) The relay shall have an adjustable characteristics angle setting range of 30 - 85 degree or shall have independent resistance(R) and reactance (X) setting.  
(g) shall have two independent continuously variable time setting range of 0-3 seconds for zone-2 and 0-5 seconds for zone-3  
(h) shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)  
(i) shall have facilities for offset features with adjustable 10-20% of Zone-3 setting  
(j) shall have variable residual compensation  
(k) shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault
(l) shall have weak end in-feed feature
(m) shall be suitable for single & three phase tripping
(n) shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times rated current without damage for a period of 1 sec.
(o) shall be provided with necessary self reset type trip duty contacts for completion of the scheme (Minimum number of these trip duty contacts shall be four per phase) either through built in or through separate high speed trip relays. Making capacity of these trip contacts shall be 30 amp for 0.2 seconds with an inductive load of L/R > 10 mill seconds. If separate high speed trip relays are used, the operating time of the same shall not be more than 10 milliseconds
(p) shall be suitable for use in permissive under reach/ over reach/ blocking communication mode
(q) shall have suitable number of potential free contacts for Carrier aided Tripping, Auto reclosing, CB failure, Disturbance recorder & Data acquisition system
(r) include power swing blocking protection which shall
   • have suitable setting range to encircle the distance protection described above
   • block tripping during power swing conditions
   • release blocking in the event of actual fault
(s) include fuse failure protection which shall monitor all the three fuses of C.V.T. and associated cable against open circuit
   • inhibit trip circuits on operation and initiate annunciation
   • have an operating time less than 7 milliseconds
   • remain inoperative for system earth faults
(t) include a directional back up Inverse Definite Minimum Time (IDMT) earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built in feature or as a separate unit for 220KV transmission lines
(u) Must have a current reversal guard feature.

18.10. Back-up Directional Over Current and Earth fault protection scheme
(a) shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s)
(b) shall include necessary VT fuse failure relays for alarm purposes
(c) over current elements shall
   • have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting
   • have a variable setting range of 50-200% of rated current
   • have a characteristic angle of 30/45 degree lead
   • include hand reset flag indicators or LEDs
(d) earth fault element shall
- have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting
- have a variable setting range of 20-80% of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

18.11. **LINE OVER VOLTAGE PROTECTION RELAY** shall

(a) monitor all three phases
(b) have two independent stages
(c) stage I & II as built-in with line distance relays Main I & II respectively are acceptable
(d) have an adjustable setting range of 100-170% of rated voltage with an adjustable time delay range of 1 to 60 seconds for the first stage
(e) have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200 milliseconds for the second stage
(f) be tuned to power frequency
(g) provided with separate operation indicators (flag target) for each stage relays
(h) have a drop-off to pick-up ratio greater than 95%
(i) provide separate output contacts for each 'Phase' and stage for breaker trip relays, event logger and other scheme requirements

18.12. All trip relays used in transmission line protection scheme shall be of self/electrical reset type depending on application requirement.

19. **Circuit Breaker Protection:**

This shall include following functions:

19.1. **Numerical AUTO RECLOSING** function shall

(a) have single phase reclosing facilities
(b) have a continuously variable single phase dead time range of 0.1-2 seconds
(c) have a continuously variable reclaim time range of 5-300 seconds
(d) Incorporate a two position selector switch, from which single phase auto-reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through programming.
(e) be of single shot type
(f) have priority circuit to closing of both circuit breakers in case one and half breaker arrangements to allow sequential closing of breakers

(g) However, Auto-reclose as in built function of bay controller unit (BCU) (if supplied) provided for sub-station automation system is also acceptable.

19.2. **LOCAL BREAKER BACK-UP PROTECTION SCHEME** shall

(a) be triple pole type
(b) have an operating time of less than 15 milli seconds
(c) have a resetting time of less than 15 milli seconds
have three over current elements

be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer/reactor equipment protections

have a setting range of 20-80% of rated current

have a continuous thermal withstand two times rated current irrespective of the setting

have a timer with continuously adjustable setting range of 0.1-1 seconds

have necessary auxiliary relays to make a comprehensive scheme

be similar relays for complete scope of work as per specification

20. REACTOR PROTECTION

20.1. Differential Protection Relay shall

be triple pole type

have operation time less than 25 milli-seconds at 5 times setting

be tuned to system frequency

have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range

be high impedance / biased differential type

be stable for all external faults

20.2. Restricted Earth Fault Protection Relay shall

be single pole type

be of current/voltage operated high impedance type

have a current setting of 10-40% of 1 Amp./have a suitable voltage setting range

be tuned to system frequency

have a suitable non-linear resistor to limit the peak voltage to 1000 Volts

20.3. Back up impedance protection Relay shall

be triple pole type, with faulty phase identification/ indication

be single step polarised 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults

have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable

have an adjustable characteristic angle of 30-80 degree

have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds

include VT failure relay which shall block the tripping during VT fuse failure condition

Further, Reactor auxiliary protections contacts (Buchholz, PRV, Oil
Temperature, Winding Temperature etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.

21. TRANSFORMER PROTECTION

All transformer protection functions may be grouped into Group-I and Group-II protections in the following manner:

Group-I Protection: Following protection functions may be provided in Group-I Transformer protection relay:

a) Differential Protection as per clause no. 21.1
b) Over fluxing Protection for HV side as per clause no. 21.2
c) Direction Over current and earth fault protection for HV side as per clause no. 21.4
d) Over Load Protection as per clause no. 21.5

Group-II Protection: Following protection functions may be provided in Group-II Transformer protection relay:

e) REF Protection as per clause no. 21.3
f) Over fluxing Protection for IV/LV side as per clause no. 21.2
g) Direction Over current and earth fault protection for IV/LV side as per clause no. 21.4
h) Neutral Current Relay for Single Phase Transformer Bank

The various protections as built-in function of Group I/II protections shall be accepted only if the functional requirements of corresponding protections as specified in clause no. 21.1 to 21.6 are met otherwise separate protection relay(s) shall be offered.

21.1. Transformer differential protection scheme shall

(a) be triple pole type, with faulty phase identification/ indication
(b) have an operating time not greater than 30 milli seconds at 5 times the rated current
(c) have three instantaneous high set over-current units
(d) have an adjustable bias setting range of 20-50%
(e) be suitable for rated current of 1 Amp.
(f) have second harmonic or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof feature shall not be achieved through any intentional time delay e.g. use of timers to block relay operation or using disc operated relays
(g) have an operating current setting of 15% or less
(h) include necessary separate interposing current transformers for angle and ratio correction or have internal feature in the relay to take care of the angle & ratio correction
(i) have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre fault and post fault period:

- current in all three windings in nine analogue channels in case of
400kV class and above transformers or 6 analogue channels for lower voltage transformers and Voltage in one channel

The disturbance recorder shall have the facility to record the following external digital channel signals apart from the digital signals pertaining to differential relay:

1. REF protection operated
2. HV Breaker status (Main and tie)
3. IV Breaker status
4. Bucholz /OLTC Bucholz alarm / trip etc.
5. WTI/OTI/PRD alarm/trip of transformer etc.

Necessary hardware and software, for automatic up-loading the data captured by disturbance recorder to the personal computer (DR Work Station) available in the substation, shall be included in the scope.

21.2. **Over Fluxing Protection Relays** shall

(a) operate on the principle of Voltage to frequency ratio and shall be phase to phase connected

(b) have inverse time characteristics, matching with transformer over fluxing withstand capability curve

(c) provide an independent ‘alarm’ with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of 'v/f' between 100% to 130% of rated values

(d) tripping time shall be governed by 'v/f' Vs. time characteristics of the relay

(e) have a set of characteristics for Various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at 'v/f' values of 1.4 and 1.5 times, the rated values, respectively.

(f) have an accuracy of operating time, better than ±10%

(g) have a resetting ratio of 95 % or better

21.3. **Restricted Earth Fault Protection** shall

(a) be single pole type

(b) be of current/voltage operated type

(c) have a current setting range of 10-40% of 1 Amp./ have a suitable voltage setting range

(d) be tuned to the system frequency

21.4. **Back-up Over Current and Earth fault protection scheme with high set feature**

(a) Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s).

(b) The scheme shall include necessary VT fuse failure relays for alarm purposes

(c) Over current relay shall
- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 50-200% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 500-2000 % of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs.

(d) Earth fault relay shall
- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 200-800 % of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

21.5. Transformer Overload Protection Relay shall
(a) be of single pole type
(b) be of definite time over-current type
(c) have one set of over-current relay element, with continuously adjustable setting range of 50-200% of rated current
(d) have one adjustable time delay relay for alarm having setting range of 1 to 10.0 seconds, continuously.
(e) have a drop-off/pick-up ratio greater than 95%.

21.6. Transformer Neutral Current Protection relay (for 1-Phase transformer bank neutral) shall
(a) have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current

21.7. Further, Transformer auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature, OLTC Buchholz etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.

22. TEE DIFFERENTIAL PROTECTION RELAYS
22.1. TEE-1 Differential protection relay shall
(a) be triple pole type
(b) have an operating time less than 30 milliseconds at 5 times the rated current
(c) have three instantaneous high set over current units
(d) have an adjustable bias setting range of 20-50%
(e) have an operating current setting of 15% of 1 Amp or less

22.2. **TEE-2 Differential Protection relay** shall

(a) be triple pole type
(b) have operating time less than 25 milliseconds at 5 times setting
(c) be tuned to system frequency
(d) have current setting range of 20 to 80% of 1 Amp
(e) be voltage operated, high impedance type
(f) be stable for all external faults
(g) be provided with suitable non-linear resistors across the relay to limit the peak voltage to 1000 volts

23. **TRIP CIRCUIT SUPERVISION RELAY**

(a) The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.
(b) The relay shall have adequate contacts for providing connection to alarm and event logger.
(c) The relay shall have time delay on drop-off of not less than 200 milliseconds and be provided with operation indications for each phase

24. **TRIPPING RELAY**

High Speed Tripping Relay shall

(a) be instantaneous (operating time not to exceed 10 milliseconds).
(b) reset within 20 milliseconds
(c) be D.C. operated
(d) have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger, Disturbance recorder, fault Locator, etc.
(e) be provided with operation indicators for each element/coil.

25. **DC SUPPLY SUPERVISION RELAY**

(a) The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.
(b) It shall have adequate potential free contacts to meet the scheme requirement.
(c) The relay shall have a 'time delay on drop-off' of not less than 100 milliseconds and be provided with operation indicator/flag.

26. **BUS BAR PROTECTION**

26.1. Single bus bar protection scheme shall be provided for each main bus and transfer bus (as applicable) for 220KV and 132 KV voltage levels

26.2. Each Bus Bar protection scheme shall
(a) have maximum operating time up to trip impulse to trip relay for all types of faults of 25 milli seconds at 5 times setting value.

(b) operate selectively for each bus bar

(c) give hundred percent security up to 63 KA fault level for 220KV and 31.5 KA for 132 KV

(d) incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm

(e) not give false operation during normal load flow in bus bars

(f) incorporate clear zone indication

(g) be of phase segregated and triple pole type

(h) provide independent zones of protection (including transfer bus if any). If the bus section is provided then each side of bus section shall have separate set of bus bar protection schemes

(i) include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.

(j) be transient free in operation

(k) include continuous D.C. supplies supervision

(l) not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.

(m) shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm

(n) include protection 'IN/OUT' switch for each zone

(o) shall include trip relays, CT switching relays (if applicable), auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus-bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers covered under this specification. Suitable panels (if required) to mount these are also included in the scope of the work.

(p) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard panel room where bus bar protection panel shall be installed.

26.3. Built-in Local Breaker Backup protection feature as a part of bus bar protection scheme shall also be acceptable.

26.4. At existing substations, Bus-bar protection scheme with independent zones for each bus, will be available. All necessary co-ordination for 'AC' and 'DC' interconnections between existing schemes (Panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relay, trip relay, flag relay and multi tap auxiliary CTs (in case of biased differential protection) required to facilitate the operation of the bays
covered under this contract shall be fully covered in the scope of the bidder.

26.5. The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

27. WEATHER PROOF RELAY PANELS (If Applicable)

(a) This panel shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contacts multiplication and for changing the CT and DC circuits to relevant zones of bus bar protection.

(b) The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 2.0 mm thick and properly braced to prevent wobbling.

(c) The enclosures of the panel shall provide a degree of protection of not less than IP-55 (as per IEC-60529).

(d) The panel shall be of free standing floor mounting type or pedestal mounting type as per requirement.

(e) The panel shall be provided with double hinged doors with padlocking arrangement.

(f) All doors, removable covers and panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh

(g) Cable entries shall be from bottom. Suitable removable cable gland plate shall be provided on the cabinet for this purpose.

(h) All sheet steel work shall be degreased, pickled, phosphated and then applied with two coats of zinc chromates primer and two coats of finishing synthetic enamel paint, both inside and outside. The colour of the finishing paint shall be light grey.

(i) Suitable heaters shall be mounted in the panel to prevent condensation. Heaters shall be controlled by thermostats so that the cubicle temperature does not exceed 30°C. On-off switch and fuse shall be provided. Heater shall be suitable for 230V AC supply Voltage.

(j) The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

28. FAULT RECORDER

28.1. The fault recorder shall be provided for transmission line and the fault recorder as in-built feature of line distance relay is also acceptable provided the
requirements of following clauses are met.

28.2. Fault recorder shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances.

28.3. The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit which is common for the entire Substation. Whenever, more than one acquisition units are connected to an Evaluation unit, necessary hardware and software shall also be supplied for on line transfer of data from all acquisition units to Evaluation unit.

28.4. The acquisition unit is connected with evaluation unit being supplied as described in chapter 17 sub-station automation through bus conforming to IEC 61850. In case of extension sub-station which is equipped with Sub-station Automation System based on IEC 61850, one set of evaluation software shall be supplied and loaded in existing fault recorder evaluation unit. Automatic uploading of disturbance files from acquisition unit to evaluation unit shall be done through existing station bus only conforming to IEC 61850. Necessary configuration/updation including hardware if any shall be in the scope of the contractor.

28.5. In case of extension of existing substation(s) which are without sub-station automation system, one set of Evaluation unit shall be supplied for each substation where ever disturbance recorders are required to be supplied along with necessary evaluation software as specified above. The Evaluation unit shall consist of a desktop personal computer (including at least 17" TFT colour monitor, mouse and keyboard) and printer. The desktop PC shall have Pentium - IV processor or better and having a clock speed 3.0GHz or better. The hard disk capacity of PC shall not be less than 300 GB and RAM capacity shall not be less than 3 GB.

28.6. The evaluation unit hardware, for substations having SAS, shall be as described in clause no. 4.0 of chapter sub-station automation system.

28.7. Fault recorder shall have atleast 8 analogue and 16 digital channels for each feeder.

28.8. Acquisition units shall acquire the Disturbance data for the pre fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.

28.9. The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.

28.10. The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which are prone to various interference signals typically from large switching transients.

28.11. Necessary software for transferring the data automatically from local evaluation unit to a remote station and receiving the same at the remote station through owner’s PLCC/VSAT/LEASED LINE shall be provided.
28.12. Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analogue and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analogue channel, group of signal to be drawn on the same axis etc, listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and voltage wave forms. The Disturbance records shall also be available in COMTRADE format (IEEE standard- Common Format for Transient data Exchange for Power System)

28.13. The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.

28.14. Fault recorder acquisition units shall be suitable to operate from 220V DC or 110V DC as available at sub-station. Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Fault recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in chapter sub-station automation clause no. 8.0 and DR evaluation unit.

28.15. The acquisition unit shall have the following features

(a) Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc and same shall be wired to annunciation system.

(b) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.

(c) Scan rate shall be 1000 Hz/channel or better.

(d) Pre-fault time shall not be less than 100 milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system fault occurs during one post-fault run time, the recorder shall also be able to record the same. However, the total memory of acquisition unit shall not be less than 5.0 seconds.

(e) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.

(f) The acquisition unit shall be typically used to record the following digital channels:

1. Main CB R phase open
2. Main CB Y phase open
3. Main CB B phase open
4. Main-1 carrier received
5. Main-1 protection operated
6. Main/Tie /TBC Auto reclosed operated
7. Over Voltage -Stage-1 /2 operated
8. Reactor / Stub/TEE-1/2/UF protection operated
9 Direct Trip received
10 Main-2 carrier received
11 Main-2/ Back Up protection operated
12 Bus bar protection operated
13 LBB operated of main/tie/TBC circuit breaker
14 Tie/TBC CB R phase open
15 Tie/TBC CB Y phase open
16 Tie/TBC CB B phase open

(g) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.

(h) Any digital signal can be programmed to act as trigger for the acquisition unit. Analog channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.

28.16. The colour laser printer shall be provided which shall be compatible with the desktop PC and shall use Plain paper. The print out shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analogue and digital signals of all the channels. Two packets of A4 size paper (500 sheets in each packet) suitable for printer shall be supplied.

28.17. Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to ±0.5 seconds/day, if allowed to run without synchronisation. Further, Fault recorder shall have facility to synchronise its time generator from Time Synchronisation Equipment having output of following types

- Voltage signal : (0-5V continuously settable, with 50m Sec. minimum pulse duration)
- Potential free contact (Minimum pulse duration of 50 m Sec.)
- IRIG-B
- RS232C

The recorder shall give annunciation in case of absence of synchronising within a specified time.

28.18. Substations where Time Synchronisation Equipment is not available, time generator of any one of the Fault recorders can be taken as master and time generators of other Fault recorders and Event loggers in that station shall be synchronised to follow the master.

29. DISTANCE TO FAULT LOCATOR shall

a) be electronic or microprocessor based type
b) be 'On-line' type
c) be suitable for breaker operating time of 2 cycles
d) have built-in display unit
e) the display shall be directly in percent of line length or kilometres without requiring any further calculations
f) have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays

g) The above accuracy should not be impaired under the following conditions:
   • presence of remote end infeed
   • predominant D.C. component in fault current
   • high fault arc resistance
   • severe CVT transients

h) shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line

i) built-in feature of line distance relay is acceptable provided the requirements of above clauses are met

30. TIME SYNCHRONISATION EQUIPMENT

30.1. The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronise equipments to the Nepal Standard Time in a substation.

30.2. Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.

30.3. It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.

30.4. Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80% humidity.

30.5. The synchronisation equipment shall have 2 micro-second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc).

30.6. Equipment shall meet the requirement of IEC 60255 for storage & operation.

30.7. The system shall be able to track the satellites to ensure no interruption of synchronisation signal.

30.8. The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

30.9. The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following:
   • Potential free contact (Minimum pulse duration of 50 milli Seconds.)
   • IRIG-B
   • RS232C
   • SNTP Port

30.10. The equipment shall have a periodic time correction facility of one second periodicity.

30.11. Time synchronisation equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.

30.12. Equipment shall have real time digital display in hour, minute, second (24 hour
mode) & have a separate time display unit to be mounted on the top of control panels having display size of approx. 100 mm height.

31. RELAY TEST KIT

31.1. One relay test kit shall comprise of the following equipment as detailed here under

- 3 sets Relay tools kits
- 2 nos. Test plugs for TTB
- 2 nos. Test plugs for using with modular type relays (if applicable)

32. TYPE TESTS

32.1. The reports for following type tests shall be submitted during detailed engineering for the Protective relays, Fault Recorder, Fault locator and Disturbance recorder:

a) Insulation tests as per IEC 60255-5
b) DC Voltage dips and interruptions/Variation as per IEC 61000-4-29.
c) High frequency disturbance test as per IEC 61000-4 16, Class IV (Not applicable for electromechanical relays)
d) Electrostatic discharges as per IEC 61000-4-2, level; 4 (not applicable for Electromechanical relays)
e) Fast transient test as per IEC 61000, Level IV (Not applicable for electromechanical relays)
f) Relay characteristics, performance and accuracy test as per IEC 60255
   • Steady state Characteristics and operating time
   • Dynamic Characteristics and operating time for distance protection relays and current differential protection relays
   • Conformance test as per IEC 61850-10.
   For Fault recorder, Disturbance recorder; only performance tests are intended under this item.
g) Tests for thermal and mechanical requirements as per IEC 60255-6
h) Tests for rated burden as per IEC 60255-6
i) Contact performance test as per IEC 60255-0-20 (not applicable for Distance to fault locator and Disturbance recorder)

In case there is a change either in version or in model (Except firmware) of the relay, the contractor has to submit the type test reports for the offered revision/model.

32.2. Steady state & Dynamic characteristics test reports on the distance protection relays, as type test, shall be based on test programme specified in Appendix A on simulator/network analyser/PTL. Alternatively, the files generated using Electromagnetic transient Programme (EMTP) can also be used for carrying out the above tests. Single source dynamic tests on transformer differential relay shall be/should have been conducted based on general guidelines specified in CIGRE committee 34 report on Evaluation of characteristics and performance of Power system protection relays and protective systems.
33. CONFIGURATION OF RELAY AND PROTECTION PANELS

The following is the general criteria for the selection of the equipments to be provided in each type of panel. However, contractor can optimise the requirement of panels by suitably clubbing the feeder protection and CB relay panels. It may be noted that Main-I and Main-II protections for line can not be provided in single panel. Similarly, Group-I & Group-II protections for transformer can not be provided in single panel.

**CONTROL PANEL**

Various types of control panels shall consist of the following:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Ammeter</td>
<td>3 set for each Line, BC, TBC Transformer</td>
</tr>
<tr>
<td>b</td>
<td>Ammeter with Selector switch</td>
<td>1 set for each line reactor</td>
</tr>
<tr>
<td>c</td>
<td>Wattmeter with transducer</td>
<td>1 set for each line, transformer</td>
</tr>
<tr>
<td>d</td>
<td>Varmeter with transducer</td>
<td>1 set for each line, transformer, Bus reactor</td>
</tr>
<tr>
<td>e</td>
<td>Varmeter with transducer</td>
<td>1 set for each Line Reactor</td>
</tr>
<tr>
<td>f</td>
<td>CB Control switch</td>
<td>1 no. for each Circuit breaker</td>
</tr>
<tr>
<td>g</td>
<td>Isolator Control switch</td>
<td>1 no. for each isolator</td>
</tr>
<tr>
<td>h</td>
<td>Semaphore</td>
<td>1 no. for each earth switch</td>
</tr>
<tr>
<td>i</td>
<td>Red indicating lamp</td>
<td>1 no. for each Circuit breaker</td>
</tr>
<tr>
<td>j</td>
<td>Red indicating lamp</td>
<td>1 no. for each isolator</td>
</tr>
<tr>
<td>k</td>
<td>Green indicating lamp</td>
<td>1 no. for each Circuit breaker</td>
</tr>
<tr>
<td>l</td>
<td>Green indicating lamp</td>
<td>1 no. for each isolator</td>
</tr>
<tr>
<td>m</td>
<td>White indicating lamp (DC healthy lamp)</td>
<td>2 nos for each feeder</td>
</tr>
<tr>
<td>n</td>
<td>Annunciation windows with associated annunciation relays</td>
<td>18 nos for each feeder</td>
</tr>
<tr>
<td>o</td>
<td>Push button for alarm Accept/reset/lamp test</td>
<td>3 nos for each control panel</td>
</tr>
<tr>
<td>p</td>
<td>Synchronising Socket</td>
<td>1 no. for each Circuit Breaker if required</td>
</tr>
<tr>
<td>q</td>
<td>Synchronising selector Switch</td>
<td>1 no. for each Circuit Breaker switch if required</td>
</tr>
<tr>
<td>r</td>
<td>Protection Transfer Switch</td>
<td>1 no. for each breaker in case of DMT/DM*/SMT scheme (Except TBC and BC Breaker)</td>
</tr>
<tr>
<td>s</td>
<td>Mimic to represent SLD</td>
<td>Lot in all control panels</td>
</tr>
<tr>
<td>t</td>
<td>Voltmeter with selector reactor Switch</td>
<td>1 no for each line, transformer, bus</td>
</tr>
<tr>
<td>u</td>
<td>Cut out, mounting and wiring for RWTI and selector switch</td>
<td>Lot for transformers/reactors</td>
</tr>
</tbody>
</table>

**Notes:**

1. For transformer feeders, all equipments of control panel shall be provided separately for HV and MV sides.
2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.
3. The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel shall be supplied.
4. Common synchronising switch is also acceptable in Synchronising trolley for new Substations. In this case, individual synchronising selector switch is not required for each Circuit Breaker in control panel.
5. Each line /HV side of transformer/MV/LV side of transformer /Bus reactor/TBC/BC/ Bus Section shall be considered as one feeder for above purpose.
LINE PROTECTION PANEL (220 & 132kV)

The Line Protection panel for transmission lines shall consist of following protection features/schemes

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>220kV</th>
<th>132kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main-1 Numerical Distance protection scheme</td>
<td>1 Set</td>
<td>1 Set</td>
</tr>
<tr>
<td>2</td>
<td>Main-2 Numerical Distance protection scheme</td>
<td>1 Set</td>
<td>NIL</td>
</tr>
<tr>
<td>3</td>
<td>Over Voltage Protection Scheme</td>
<td>NIL</td>
<td>NIL</td>
</tr>
<tr>
<td>4</td>
<td>Fault Recorder</td>
<td>1 Set</td>
<td>NIL</td>
</tr>
<tr>
<td>5</td>
<td>Distance to fault Locator</td>
<td>1 Set</td>
<td>1 Set</td>
</tr>
<tr>
<td>6</td>
<td>3 Phase Trip Relays</td>
<td>2 Nos.</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>7</td>
<td>Flag relays, carrier receive relays, aux. Relays, timers etc as per scheme requirements</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td>8</td>
<td>Under Voltage protection relay for isolator/earth switch</td>
<td>2 Nos.</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>9</td>
<td>Cut-out and wiring with TTB for supplied energy meter</td>
<td>1 Set</td>
<td>1 Set</td>
</tr>
<tr>
<td>10</td>
<td>Directional Back up Over current and E/F protection scheme</td>
<td>1 Set</td>
<td>1 Set</td>
</tr>
</tbody>
</table>

In a substation where 220 KV lines are under the scope of the contract, bidder is required to give identical Main-1 and Main-2 distance protection schemes for all voltage levels.

a) 33 KV LINE CONTROL & PROTECTION PANEL (For Substation with Automation)

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>DESCRIPTION</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bay Control Unit/Bay Control &amp; Protection Unit</td>
<td>1NO.</td>
</tr>
<tr>
<td>2</td>
<td>Numerical Non Directional Over Current and Earth Fault Relay 1No.with High Set Feature and in built LBB protection( LBB function as part of BCU is acceptable)</td>
<td>1NO.</td>
</tr>
<tr>
<td>3</td>
<td>Electronic Trivector Meter with 0.2 Class Accuracy With RS 485, RS 232 &amp; Front Optical port</td>
<td>1NO.</td>
</tr>
<tr>
<td>4</td>
<td>Master Trip Relay with adequate no of contacts 1 No. and Electrical Resettable type</td>
<td>1NO.</td>
</tr>
<tr>
<td>5</td>
<td>CB Troubles and Alarm (Part of BCU)</td>
<td>1 SET</td>
</tr>
<tr>
<td>6</td>
<td>Metering (part of BCU)</td>
<td>1 SET</td>
</tr>
</tbody>
</table>
b) **132/33kV TRANSFORMER CONTROL & PROTECTION RELAY PANEL**

I. The protection panel for 132/33kV Transformer shall consist of the following equipments.

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>132kV Side</th>
<th>33kV Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer Differential protection scheme</td>
<td>1 no</td>
<td>NIL</td>
</tr>
<tr>
<td>Restricted Earth fault protection scheme</td>
<td>1 no</td>
<td>1 no</td>
</tr>
<tr>
<td>Directional back up over current and E/F Relay</td>
<td>1 set</td>
<td>Nil</td>
</tr>
<tr>
<td>With non-directional high set feature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Directional back up over current and E/F Relay with non-directional high set feature</td>
<td>NIL</td>
<td>1 Set</td>
</tr>
<tr>
<td>(Part of 33kV BCU is acceptable)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over fluxing protection scheme</td>
<td>Nil</td>
<td>1 No.</td>
</tr>
<tr>
<td>Over load protection scheme</td>
<td>1 No.</td>
<td>Nil</td>
</tr>
<tr>
<td>Three phase trip relays</td>
<td>2 No.</td>
<td>2 No.</td>
</tr>
<tr>
<td>Trip supervision relay</td>
<td>2 No.</td>
<td>2 No.</td>
</tr>
<tr>
<td>Scheme requirements including transformer Alarms and trip function</td>
<td>Lot</td>
<td>Lot</td>
</tr>
<tr>
<td>Disturbance Recorder</td>
<td>1 No.</td>
<td>------</td>
</tr>
<tr>
<td>Revenue Energymeter (As per T.S. Chapter-1)</td>
<td>1 No.</td>
<td>1 No.</td>
</tr>
</tbody>
</table>

$ BCU for 220kV&132kV Bays has been included in the BOQ details of SAS.

c) **33kV BREAKER RELAY PANEL**  
(Acceptable as Part of Line /transformer Relay panel)

The breaker relay panel for 33kV shall comprise of the following:

Without A/R

1. DC supply supervision relay  
2 no.

2. Trip circuit supervision relays  
2 nos.

3. Emergency CB TNC Switches  
1 No.

4. Flag relays, aux. relays, timers, trip relays etc.  
Lot  
As per scheme requirements.  
(Acceptable as part of BCU)

d) **TRANSFORMER PROTECTION PANEL (220/132kV)**

The protection panel for Auto transformer/Transformer shall consists of the following features/schemes:
### Transformer Differential Protection scheme
- Qty: 1 Nos.
- Note: Not applicable for auto-transformer

### Restricted Earth fault protection scheme
- Qty: 1 no.
- Note: @ Not applicable for auto-transformer

### Directional back up O/C and E/F relay with non directional high set feature
- Qty: 1 set

### Over Fluxing Protection scheme
- Qty: 1 no.

### Overload protection scheme
- Qty: 1 nos.

### Three phase trip relays
- Qty: 2 nos.

### CVT selection relays as per scheme requirement
- Qty: Lot

### Cut-out and wiring with TTB for supplied energy meter
- Qty: 1 set

### Transformer Neutral Current relay for 1-Phase transformer bank
- Qty: 1 Set

### Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, OLTC etc. as per scheme requirements
- Qty: As required

The above protection schemes may be clubbed in Group-I/II as per clause no. 21 of technical specification.

e) **REACTOR PROTECTION PANEL (220kV & 132kV)**

The protection panel for Reactor shall consist of the following protection features/schemes:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reactor Differential Protection scheme</td>
<td>1 no.</td>
</tr>
<tr>
<td>2</td>
<td>Restricted Earth fault Protection scheme</td>
<td>1 no.</td>
</tr>
<tr>
<td>3</td>
<td>Reactor back up impedance protection scheme</td>
<td>1 set</td>
</tr>
<tr>
<td>4</td>
<td>Three phase trip relays</td>
<td>2 nos.</td>
</tr>
<tr>
<td>5</td>
<td>CVT selection relay as per scheme requirement</td>
<td>Lot</td>
</tr>
<tr>
<td>6</td>
<td>Flag Relays/Aux. Relays for wiring Reactor auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, OLTC etc. as per scheme requirements</td>
<td>As required</td>
</tr>
</tbody>
</table>

f) **BREAKER RELAY PANEL (220kV & 132kV)**

The breaker relay panel shall comprise of the following:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>With A/R</th>
<th>Without A/R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Breaker failure Protection Scheme</td>
<td>1 No.</td>
<td>1 No.</td>
</tr>
<tr>
<td>2</td>
<td>DC supply Supervision relay</td>
<td>2 Nos.</td>
<td>2 Nos.</td>
</tr>
</tbody>
</table>
3. Trip Circuit supervision relays# 6 Nos. 6 Nos.
4. Auto-reclose scheme (if standalone) 1 Nos. NIL
5. Flag relays, aux relays, timers, trip relays as per scheme requirements As required As required

# Trip supervision relays shall be 2 or 6 numbers as per no. of trip coils for each 132KV Circuit breaker

Note: Equipment/relays to be provided under CB Relay Panel may be accommodated in the Protection Panels to be provided for Transmission Line/Transformer/Reactor as applicable.

34. ERECTION AND MAINTENANCE TOOL EQUIPMENTS
All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished in relevant schedule

35. TROPICALISATION
Control room will be normally air-cooled/air-conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot, humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to tropical environment.
Test programme for distance relays

General Comments:

1. These test cases are evolved from the report of working group 04 of study committee 34 (Protection) on evaluation of characteristics and performance of power system protection relays and protective systems. For any further guidelines required for carrying out the tests, reference may be made to the above document.
2. The test shall be carried out using network configuration and system parameters as shown in the figure-1
3. All denotations regarding fault location, breakers etc are referred in figure –1
4. The fault inception angles are referred to R- N voltage for all types of faults
5. The fault inception angle is zero degree unless otherwise specified
6. Where not stated specifically, the fault resistance (Rf) shall be zero or minimum as possible in simulator
7. Single pole circuit breakers are to be used
8. The power flow in double source test is 500 MW

System parameters
System voltage =400KV
CTR= 1000/1
PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure –2)

Line parameters/km
Positive Sequence Resistance, \(r_1\) = 0.02897 Ω
Positive Sequence Reactance \(x_1\) = 0.3072 Ω
Zero Sequence Resistance \(r_0\) = 0.2597 Ω
Zero Sequence Reactance \(x_0\) = 1.0223 Ω
Zero Sequence Mutual Resistance \(r_m\) = 0.2281 Ω
Zero Sequence Mutual Reactance \(x_m\) = 0.6221 Ω
Zero Sequence susceptance \((b_0)\) = 2.347 \(\mu\) mho  
Positive Sequence susceptance \((b_1)\) = 3.630 \(\mu\) mho  

<table>
<thead>
<tr>
<th>Type of line</th>
<th>Short</th>
<th>Long</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary line impedance</td>
<td>2 (\Omega)</td>
<td>20 (\Omega^*)</td>
</tr>
<tr>
<td>Length of line in Kms</td>
<td>23.57</td>
<td>235.7</td>
</tr>
<tr>
<td>SIR</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Source impedance ((\text{pry})) (at a time constant of 50 ms)</td>
<td>29.09 (\Omega) (5500 MVA)</td>
<td>109.09 (\Omega) (1467 MVA)</td>
</tr>
</tbody>
</table>

* Alternatively, the tests can be done with 10 \(\Omega\) secondary impedance and source impedance may accordingly be modified

CVT Model

![CVT Model Diagram](image)

| \(X_{C1}\) | 1.455 \(\mu\) mho |
| \(X_{C2}\) | 27.646 \(\mu\) mho |
| \(R_I\) | 320 \(\Omega\) |
| \(X_{LI}\) | 34243 \(\Omega\) |
| \(R_a\) | 4200 \(\Omega\) |
| \(X_{La}\) | 197.92 \(\Omega\) |
| \(R_c\) | 14.00 \(\Omega\) |
Transformation ratio of 181.8
Intermediate transformer

Details of fault cases to be done

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Description</th>
<th>Single source with short line (2 Ω)</th>
<th>Single source long line (20 Ω)</th>
<th>Double source with short double line (2 Ω)</th>
<th>Double source with long single line (20 Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CLOSE C1, OPEN C2,C3,C4</td>
<td>CLOSE C1, OPEN C2,C3,C4</td>
<td>CLOSE C1, OPEN C2,C3,C4</td>
<td>CLOSE C1,C3 OPEN C2,C4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SIR=4</td>
<td>SIR=15</td>
<td>SIR =4</td>
<td>SIR=4</td>
</tr>
<tr>
<td>1</td>
<td>Dynamic accuracy for zone 1</td>
<td>Tests to be done at 2 locations (84% and 76% of line length) X 4 faults (RN, YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases</td>
<td>Tests to be done at 2 locations (84% and 76% of line length) X 4 faults (RN, YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases</td>
<td>Tests to be done at 2 locations (84% and 76% of line length) X 4 faults (RN, YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases</td>
<td>Tests to be done at 2 locations (84% and 76% of line length) X 4 faults (RN, YB, YBN, RYB) X 2 fault inception angle (0°, 90°)= 16 cases</td>
</tr>
<tr>
<td>2</td>
<td>Operating time for zone 1 at SIR =4</td>
<td>Tests to be done at 3 locations (0%, 40% and 64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°, 30°, 60° and 90°) = 48 cases</td>
<td>Tests to be done at 3 locations (0%, 40% and 64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°, 30°, 60° and 90°) = 48 cases</td>
<td>Tests to be done at 3 locations (0%, 40% and 64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°, 30°, 60° and 90°) = 48 cases</td>
<td>Tests to be done at 3 locations (0%, 40% and 64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°, 30°, 60° and 90°) = 48 cases</td>
</tr>
<tr>
<td>3</td>
<td>Operating time for zone II and Zone III</td>
<td>Tests to be done at 1 location (100% of line)</td>
<td>Tests to be done at 1 location (100% of line)</td>
<td>Tests to be done at 1 location (100% of line)</td>
<td>Tests to be done at 1 location (100% of line)</td>
</tr>
<tr>
<td>Sl no</td>
<td>Description</td>
<td>Single source with short line (2 Ω)</td>
<td>Single source long line (20 Ω)</td>
<td>Double source with short double line (2 Ω)</td>
<td>Double source with long single line (20 Ω)</td>
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<td>-------</td>
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<td>--------------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>length ) X 1 faults (RN, YB, YBN, RYB) X 2 zones (II and III) = 2 cases</td>
<td>length ) X 1 faults (RN, YB, YBN, RYB) X 2 zones (II and III) = 2 cases</td>
<td>length ) X 1 faults (RN, YB, YBN, RYB) X 2 Zones (II and III) = 2 cases</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Switch on to fault feature</td>
<td>Tests to be done at 2 location (0 % and 32 %) X 1 faults (RYB) Any fault inception angle = 2 cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Operation during current reversal</td>
<td>Tests to be done at 2 location (0 % and 80 % of line length) X 1 faults (RN) X 1 fault inception angle (0 degrees) = 2 cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CLOSE C1, OPEN C2,C3,C4</td>
<td>CLOSE C1, OPEN C2,C3,C4</td>
<td>CLOSE C1, C2,C3,C4</td>
<td>CLOSE C1,C3 OPEN C2,C4</td>
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<tr>
<td></td>
<td></td>
<td>SIR=4</td>
<td>SIR=15</td>
<td>SIR =4</td>
<td>SIR=4</td>
</tr>
<tr>
<td>6</td>
<td>Operation at simultaneous faults</td>
<td>Tests to be done at 2 location (8 % and 64 % of line length) X 2 faults (RN in circuit 1 to BN in circuit 2 and RN in circuit 1 to RYN in circuit 2 in 10 ms) X 1 fault</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

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<table>
<thead>
<tr>
<th>Sl no</th>
<th>Description</th>
<th>Single source with short line (2 Ω)</th>
<th>Single source long line (20 Ω)</th>
<th>Double source with short double line (2 Ω)</th>
<th>Double source with long single line (20 Ω)</th>
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</tr>
<tr>
<td>7</td>
<td>Directional sensitivity</td>
<td></td>
<td></td>
<td></td>
<td>Tests to be done at 1 location (0% reverse) X 6 faults (RN, YB, YBN, RYB, RN with (R_f=13.75) ohm(sec) and RYN with (R_f=13.75) Ohm (sec) X 2 fault inception angle (0° ,90°) = 12 cases</td>
</tr>
<tr>
<td>8</td>
<td>Limit for fault resistance</td>
<td></td>
<td></td>
<td></td>
<td>Tests to be done at 2 location (0% and 68% of line length) X 1 fault (RN with (R_f=13.75) Ohm (sec) X 2 fault inception angle (0°, 90°) = 4 cases</td>
</tr>
<tr>
<td>9</td>
<td>Operation at evolving faults</td>
<td></td>
<td></td>
<td></td>
<td>Tests to be done at 2 location (32% and 0% of line length) X 2 faults (RN to RYN) x in 2 timings (10 ms and 30 ms) X 2 load direction (from A to B and from B to A) = 16 cases</td>
</tr>
<tr>
<td>9</td>
<td>Fault locator function, in</td>
<td>Measure fault location for all</td>
<td>Measure fault location</td>
<td>Measure fault location</td>
<td>Measure fault location</td>
</tr>
<tr>
<td>Sl no</td>
<td>Description</td>
<td>Single source with short line (2 $\Omega$)</td>
<td>Single source long line (20 $\Omega$)</td>
<td>Double source with short double line (2 $\Omega$)</td>
<td>Double source with long single line (20 $\Omega$)</td>
</tr>
<tr>
<td>------</td>
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<tr>
<td></td>
<td>cases the same is offered as built in feature</td>
<td>cases under 1 and 2</td>
<td>for all cases under 1 and 2</td>
<td>for all cases under 1 and 2</td>
<td>for all cases under 2 and 6</td>
</tr>
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## CHAPTER 16: EHV XLPE POWER CABLE

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</tr>
<tr>
<td>34</td>
<td>OPTICAL FIBRE CABLE (For Communication Equipments)</td>
</tr>
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</table>
EHV XLPE POWER CABLE

1 CABLE CONSTRUCTION DETAILS

1.1 The XLPE insulated EHV cable shall conform to the requirements of IEC 60502-2 (applicable clauses only) for construction and IEC 60840/IEC 62067 (as applicable) for testing. The terminating accessories shall conform to IEC 60840/ IEC 62067 (as applicable). The offered cables and its terminating accessories shall be compatible with each other.

1.2 The EHV grade cable shall be single core, unarmoured, stranded, compacted Aluminium/Copper (as specified in BPS) conductor, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, cross linked polyethylene (XLPE) dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non woven tape with water swellable absorbent over insulation screen, followed by radial sealing (Metal sheath of Lead alloy ‘E’), metallic screening by concentric layer of plain copper wire (if required) to meet short time current requirement, followed by an open helix of copper & overall HDPE sheathed & graphite coated and conforming to the technical particulars of specification. Bidder may offer necessary layers such as separation tape, binder tapes etc additionally as per their manufacturing practices for meeting required performance of the offered cable.

1.3 The cable shall be suitable for laying under the climate conditions (as specified in Section-Project) and underground buried installation with uncontrolled back fill and chances of flooding by water.

1.4 Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

1.5 Progressive sequential marking of the cable length (in metres), at every one metre, shall be provided on the outer sheath of the cable.

1.6 Repaired cables shall not be accepted.

1.7 Allowable tolerance on the overall diameter of the cables shall be ± 2 mm.

1.8 CONDUCTOR

The conductor shall be of Copper/Aluminium wires as specified in the Bid Price Schedule (BPS). The shape of conductor shall be compacted segmental having high compactness and smooth surface finish.

1.9 CONDUCTOR SCREEN

The conductor screen shall consist of extruded semi-conducting XLPE. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor XLPE. The conductors screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.
1.10 INSULATION

The extruded XLPE insulation shall be applied over the conductor screen to the desired thickness in a void free manner.

1.11 INSULATION SCREEN

The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE.

1.12 MOISTURE BARRIER

Longitudinal water barrier:
The longitudinal water barrier shall be applied over insulation screen by a layer of non woven synthetic tape with suitable water swellable absorbent.

Radial Moisture Barrier:
This shall be of extruded Lead alloy “E” sheath.

1.13 METALLIC SCREEN:

The metallic screen shall be of plain copper wires, helically applied over the radial moisture barrier. A binder tape of annealed plain copper shall be applied in the form of an open helix over the copper wire screen. The combination of the metallic sheath (lead sheath) in combination with wire screen shall be designed to meet the requirement of the system short circuit rating as specified in the bidding documents.

1.14 OUTER SHEATH

The outer sheath shall consist of extruded black coloured HDPE with graphite coating. The outer sheath shall be suitably designed by the addition of chemicals in the outer sheath for protection against termite and rodent attack and shall be coated with graphite.

1.15 RATING

The contractor/ manufacturer shall declare current rating of cable for maximum conductor temperature of 90 degree C under continuous operation and 250 degree C during short-circuit condition. The contractor/ manufacturer shall also declare over load curve with duration for conductor temperature of 105 Deg C. A complete set of calculation made in arriving at the current rating shall be furnished, for laying condition envisaged under the project, during detailed engineering for Employer/Owner’s reference.

1.16 CABLE JOINTING ACCESSORIES

1.16.1 The cable jointing accessories shall include all the straight through joints, Cross bonding, earth continuity cables, Link boxes, Sheath Voltage Limiters (SVLs) etc as required for entire cable route. Bidder shall arrange all special tools and tackles required for making these joints at his own cost. Unless specified separately in BPS, cable end terminating kits shall be deemed included as part of cable jointing accessories.
1.16.2 The straight through joint shall preferably be built up from the same material as the main
cable and shall have electrical and mechanical withstand capabilities same as or better
than the main cable. The joints shall be suitable for tropical conditions as specified in
Section-Project.

1.16.3 The straight through joints and cable end terminations shall be of proven design and should
have been type tested as per relevant IEC. A list of supply of cable jointing accessories
which are in successful operation in projects, shall be furnished.

1.16.4 The detailed description on jointing procedure shall be furnished during detailed
engineering.

1.16.5 The cable end terminations shall be of anti-fog type and shall be of Polymer type/Porcelain
type suitable for withstanding the climatic conditions with required Creepage distance as
specified in bidding documents. The cable end terminals for terminating the cables shall
be complete with accessories & fully compatible with the cables to be supplied. The
terminations shall also be capable to withstand mechanical forces during normal and short
circuit operations.

1.16.6 The cable end terminations envisaged for mounting on Transmission Line (T/L) Towers
shall necessarily be of Composite Polymer type to reduce the weight on T/L towers. The
cable end terminations envisaged for GIS interface, shall comply to IEC 60840. It will be
the responsibility of the contractor to ensure smooth interface with GIS equipment.

2 CABLE DRUMS

2.1 Cables shall be supplied in returnable steel drums of heavy construction of suitable size
and packed conforming to applicable standards.

2.2 Standard drum lengths for manufacturing shall be finalised during detailed engineering.
Each drum shall carry the manufacturer's name, the purchaser's name, address and
contract number and type, size and length of the cable, net and gross weight stencilled on
both sides of drum. A tag containing the same information shall be attached to the leading
end of the cable. An arrow and suitable accompanying wording shall be marked on one
end of the reel indicating the direction in which it should be rolled.

2.3 Packing shall be sturdy and adequate to protect the cables from any injury due to
mishandling or other conditions encountered during transportation, handling and storage.
Both cable ends shall be sealed with PE/Rubber caps so as to eliminate ingress of water
during transportation and erection.

3 TESTS ON CABLES

All XLPE insulated EHV cables shall conform to all Type, Routine and Acceptance tests
listed in the relevant IEC & shall submit the type test reports for Employer’s approval. If
specified in Section-Project, Type tests shall be carried out on the EHV cable as per
relevant standard.

4 TESTS ON ACCESSORIES
Contractor shall submit type test reports for accessories, as per IEC 60840:1999/IEC 62067 for Employer’s acceptance. Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for Employer’s acceptance.

5 TESTS AFTER INSTALLATION

All tests on cable system as prescribed in IEC 60840:1999/IEC 62067 (as applicable) shall be performed after installation.

6 LAYING AND INSTALLATION

6.1 The bidder is advised to visit the site and acquaint themselves with the topography, infrastructure etc. The contractor shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the erection and successful commissioning of XLPE cables in all respects.

6.2 Cables shall be laid in the trench throughout the route. Further, as per requirement of the field, the cables shall also have to be laid in the followings (with prior approval of owner):

   a. In ducts
   b. In HDPE pipes (pipes to be filled with sand/suitable material after cabling)
   c. In air at terminations
   d. At varying depths due to obstructions
   e. As per approved drawings

6.3 At places where the cables cross private roads, gates of residential houses or buildings, the cables shall be laid in HDPE pipes of adequate strength.

6.4 Concrete trenches with precast covers may be used in exceptional cases in smaller portions, wherever bending of cables are involved and HDPE pipes can’t be laid.

6.5 The arrangement of laying the cable en-route shall be submitted by contractor during detailed engineering for Employer’s acceptance.

7 TRENCHING

7.1 The cable trench work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be left as clean as possible.

7.2 The trench shall be excavated using manual/mechanical modes as per field conditions. Most main roads are of asphalt surface and some of the roads with cement concrete surface. The sides of the excavated trenches shall wherever required, be well shored up.

7.3 Where paved footpaths are encountered, the pavement slabs shall be properly stored and reinstated. Identification markers of other services shall be properly stored and restored. The excavated material shall be properly stored to avoid obstruction to public and traffic movement.

7.4 Suitable barriers should be erected between the cable trench and pedestrian/motorway to prevent accidents. The barriers shall be painted with yellow and black or red and white
coloured cross stripes. Warning and caution boards should be consciously displayed. Red lights as warning signal should be placed along the trench during the nights.

7.5 The bottom of the excavated trench should be levelled flat and free from any object which would damage the cables. Any gradient encountered shall be gradual.

8 TREFOIL/FLAT FORMATION

Cables shall be laid in trefoil/flat formation (as per bidding documents) for entire route. The contractor shall submit drawings and arrangements for Employer approval.

9 CABLE HANDLING

The inspection of cable on receipt, handling of cables, paying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surfaces, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in accordance with acceptable standard practices/statutory requirements.

10 DAMAGE TO PROPERTY

The contractor shall take all precautions while excavation of trench, trial pits etc., to protect the public and private properties and to avoid accidental damage. Any damage so caused shall be immediately repaired and brought to the notice of the concerned and to the Employer. The contractor shall bear all responsibilities and liabilities and shall bear all costs of the damages so caused by him or by his workman or agents.

11 CABLE ROUTE MARKERS/CABLE JOINT MARKERS

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per approved drawings.

Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible and above ground surface.

The marker should incorporate the relevant information such that the name of the Owner, voltage, circuit and distance of cable from the marker.

12 DEPTH OF LAYING OF CABLES

Depth of laying shall be as per drawing enclosed with Specification. Laying at varying depths due to obstructions/site conditions may be accepted in extreme cases with prior approval of Employer during detailed engineering.

13 PAYING OUT THE CABLE

The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before paying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out at uniform intervals. The paying out process must be smooth and steady without subjecting the cable to abnormal tension. The cable on being paid out shall be smoothly and evenly transferred to the ground after providing the cushion.
The cables shall never be dropped. All snake bends shall be straightened. Suitable size cable stocking pulling eye shall be used for pulling the cable. While pulling the cable by winches or machines, the tension/loading shall be monitored by tension indicator and shall not exceed the permissible value for the cable. The cable laying shall be performed continuously at a speed as recommended by manufacturer.

The cable end seals shall be checked after laying and if found damaged shall immediately be resealed. Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work. The integrity of the outer sheath shall be checked after the cable is laid in position.

14 SAND BEDDING

The cable shall be completely surrounded by well-compacted cable sand to such a thickness and of such size that the cable is protected against damage (applicable where cables are not to be laid in pipes).

15 SNAKING

Snaking shall be done at necessary places recommended by manufacturer with prior approval of Employer.

16 THERMAL BACKFILL

If specifically mentioned in Section-Project, Thermal Backfilling shall be carried out based on the evaluation of soil thermal resistivity along the cable route and after approval from the Employer the contractor shall design, specify, supply, lay and monitor the installation of thermal backfill surrounding the cables. Thermal back fill shall be of thermal resistivity of 1.20 Km/W or better.

17 IMMEDIATE ENVELOPE TO CABLE

The option on the use of the material that immediately envelopes the cable viz., thermal backfill or sand or sieved native soil rests with the Employer/Owner. The contractor shall seek prior approval on the use of the envelop material from the Employer/Owner before execution of the works.

18 BACK FILLING

Normally back filling shall consist of the material earlier excavated. However, bigger stones or pieces of rock should be removed.

19 WARNING TAPE

A pre-warning, Red colour plastic/PVC tape, of atleast 250 mm wide 100 microns thick, shall be laid at approx. 0.4 m above the cable specified depth, throughout the cable route. The tape shall carry the legend printed in black continuously as under CAUTION; OWNER, VOLTAGE CLASS of CABLES.

20 PREVENTION OF DAMAGE DUE TO SHARP EDGES
After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench. Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable. While pulling through pipes and ducts, the cable shall be protected to avoid damage due to sharp edges. The cables shall never be bent, beyond the specified bending radius.

21 **ROAD, RAIL & CANAL CROSSINGS**

21.1 The road cutting, whether cement concrete asphalt or macadam road surface; Railway track crossing and canal crossing shall be taken after obtaining approval for cutting/crossing from the concerned authorities i.e. civic authorities, traffic police, telephone authorities, Railway authorities, Irrigation deptt etc., and work should be planned to be completed in the shortest possible time. Where necessary the work shall be planned during night or light traffic periods. HDPE pipes shall be used for crossing. HDPE pipes diameter should not be less than 1.5 times the cable diameter.

21.2 **Trenchless Digging:**

It is envisaged that trenchless digging shall be used for crossing the National highways, Railway tracks and Canals etc. and the same shall be in the scope of bidder. Trenchless digging shall also be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of underground cables. The trenchless digging methods shall generally conform to ITU-T L.38. The various methods of trenchless digging such as hand/manual auguring (up to 15m), impact moling (from 16m to about 40-50m), HDD (above 40-50m) shall be adopted based on the soil/site conditions and the requirement. The exact method for trenchless digging shall be finalised during detail engineering as per actual site/soil condition. The equipment used for HDD shall be capable of drilling at least 100m at one go. The contractor shall propose the exact methods and procedures for implementation of trenchless digging at various crossings taking into consideration the following guidelines, for approval by the Employer.

a) Excavation and backfilling of trial pits and verification of soil condition  
b) Excavation of entry and Exit pits  
c) Erection of drill machine for Drilling of pilot hole  
d) Placement and driving hand augur  
e) Placement and carrying out impact moling  
f) Reaming and widening of bore holes in steps (if required)  
g) Pulling of product pipe

22 **FOOTPATH CUTTING**

The slabs, kerbstones, on the roads shall be removed and reinstated without damage.

23 **REINSTATEMENT**

After the cables and pipes have been laid and before the trench is backfilled all joints and cable positions should be carefully plotted and preserved till such time the cable is energized and taken over by the Engineer in charge. The protective covers shall then be provided, the excavated soil riddled, sieved and replaced. It is advisable to leave a crown
of earth not less than 50 mm and not more than 100 mm in the centre and tapering towards the sides of the trench.

The temporary reinstatement of roadways should be inspected at regular intervals, more frequently in rainy season and immediately after overnight rain for checking settlement and if required the temporary reinstatement should be done.

After the subsidence has ceased the trench may be permanently reinstated and the surface restored to the best possible condition.

**24 MANHOLES**

Manholes shall be provided at every proposed joint location for jointing bays. The bidder shall identify the location of the joint bays after carrying out detailed survey of the cable route and excavation of the trial pits. The delivery lengths of the cables shall match the location.

The Contractor shall get inspected, by a representative of the Employer, all manholes before carrying out the backfilling. Pipe & cable sealing, installation of joint box and cable service loops as per approved drawings shall be visually inspected and checked for tightness.

The contractor shall submit design and drawing of joint bay including manholes for withstanding a live load of 20 ton vehicle plus 30% for impact from moving vehicle. The Contractor shall propose a suitable procedure for testing the manhole for approval by the Employer. Manholes type approved by the Employer only shall be acceptable. The manhole shall include sufficient number of suitable entries.

**25 TOOLS AND PLANTS**

The successful bidder shall arrange, at his own cost, all necessary tools, plant and equipment to carry out the survey and cable installation work. The bidders are instructed to give all the details of equipment at their disposal, to carry out the work successfully and speedily.

**26 BENDING RADIUS**

The minimum bending radius of XLPE insulated cables shall be 20XD where “D” means the Outer diameter of the cable.

**27 JOINTING AND TERMINATION OF CABLES**

The cable jointing personnel and his crew shall have good experience in the type of joints and terminations that are used. The jointing work shall commence as soon as two or three lengths of cables have been laid. All care should be taken to protect the factory-plumbed caps/ seals on the cable ends, and the cable end shall be sealed whenever the end is exposed for tests.

Jointing of cables in carriage ways, drive ways under costly pavings, under concrete or asphalt surfaces and in proximity to telephone cables and water mains should be avoided whenever possible.
Sufficient overlap of cables shall be allowed for making the joints.

The joint bay should be of sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed.

The joints of different phases shall be staggered in the jointing bay.

**27.1 SUMPHOLES**

When jointing cables in water logged ground or under unforeseen rainy conditions, a sumphole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or baled out by buckets, without causing interference to the jointing operation.

**27.2 TENTS/COVERS**

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open, irrespective of the weather conditions. The joint shall be made in dust free, moisture free and clean atmosphere.

**27.3 PRECAUTIONS BEFORE MAKING A JOINT**

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/inclement weather conditions, which might become uncontrollable.

If the cable end seals or cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

**27.4 MEASUREMENT OF INSULATION RESISTANCE**

Before jointing, the insulation resistance of both sections of cables shall be checked.

**27.5 IDENTIFICATION**

The identification of each phase, shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

**27.6 MAKING A JOINT**

Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.

The materials used in the joints like ferrules, screen/sheath continuity bonds, lugs etc., shall be of good quality and conform to standards.

The jointing tools shall be appropriate and as per the requirement of jointing EHV XLPE cables.
28 CABLE LAYING & TERMINATIONS

The preparation of the cable end for installing the terminations and the precautions to be taken before fixing the terminations shall be followed as in the case of the cable jointing procedures. The instructions furnished by the termination manufacturer shall be strictly followed.

At cable terminating end, the following provisions for supply and erections are to be included:

(i) A sufficient length of spare cable shall be left in the ground, for future needs.
(ii) The rise of the cable immediately from the ground shall be enclosed in PVC/PE pipe of suitable diameter to protect against direct exposure to the sun.
(iii) The cable shall be properly fastened using non-metallic clamps.
(iv) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.
(v) The sealing end shall be mounted on pedestal insulators to isolate them from their supporting steel work.
(vi) Protection from contact with the exposed metal work at the termination shall be provided by resin bonded glass fibre shroud.
(vii) Providing earth stations with all required materials, like leads, connectors etc. Earth pits shall conform to IS–3043:1987 (Code of practice for earthing)/ or equivalent International standards.

29 BONDING OF SCREEN/ SHEATH

The screens/sheath shall be cross-bonded under each segment of specified route in accordance with IS-3043 (Code of practice for earthing) or applicable International codes & practices. The bidder shall offer complete cable system in order to limit maximum sheath voltage in accordance with relevant standards and furnish complete set of calculations in support of the same. The screen/sheath shall be connected to the earth stations/ earth pits through disconnecting type link boxes & through Sheath Voltage Limiter (SVL) as required.

All required materials used in the Cross bonding, termination of earth continuity cable, Link box, SVL etc to comply with specification/statutory requirements shall be in the scope of bidder and should be of good quality and compatible with the cable.

30 CONNECTION OF RADIAL WATER BARRIER AND CABLE SCREEN

If the metallic radial water barrier is insulated from the metallic wire screen, a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

31 CABLE TERMINATING STRUCTURES

31.1 The terminating structure being supplied, should be designed as per the project requirement for the cable end terminations i.e. for Standalone Outdoor AIS terminations, GIS end terminations and Transmission line Tower end terminations as per requirement specified in BPS.
31.2 The mounting structure shall be fixed on the reinforced cement concrete foundation, the design & drawings of which shall be submitted to Employer for review & acceptance during detailed engineering.

31.3 The mounting structure includes the supports for cable end boxes, link boxes and any other item required for the intent of the contract. All steel sections used shall be free from all imperfections, mill scales, slag intrusions, laminations, fillings, rust etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Employer. The steel for mounting structure shall confirm to IS-2062 (latest).

31.4 In case of cable terminations on transmission line towers, the cable termination kit, LA, Link Box, SVL etc shall be fixed suitably on the tower for which necessary interface details shall be coordinated for Tower design during detailed engineering. After fixing the end terminations, the cable shall be suitably fixed to the tower members, with non-magnetic material clamps to the required height securely. The cable in air shall be suitably protected using HDPE pipes up to certain height.

31.5 In case of GIS end terminations, the structure & foundations shall be suitably designed in coordination with GIS terminations during detailed engineering.

32 MEASUREMENT (for Civil Works)

The buried cable trench shall be measured in the running meters including excavation, backfilling, thermal back filling (if applicable), compaction, laying of concrete/reinforcement, placing of warning tap markers, dewatering as required as per the drawing & specification & any other job required for successful completion of work.

33 DISTRIBUTED TEMPERATURE MONITORING SYSTEM (DTS)

The bidder shall include and provide separate “Distributed Temperature Monitoring System (DTS)” for entire route for EHV cables complete in all respects along with terminal coupling equipment, workstation and all required hardware & software for real-time monitoring of conductor temperature profile and to provide load predictions. The offered system should be able to provide maximum possible transmission capacity of the cable for each circuit. The distributed temperature monitoring system shall be optical fibre based, must be of proven technology and should be in operation for similar use along with EHV cables as per latest practices. The “terminal coupling equipment” and “workstation” shall preferably be microprocessor based with HMI, for displaying temperature along the length of the cable system. System shall provide potential free output contact for signalling to SCADA. The bidder shall provide brochures and catalogues for offered distributed temperature monitoring system along with the bid.

Optical fibre cables along with all jointing accessories etc required for DTS shall also be included in the scope of bidder. Optical fibre cables associated with DTS shall be laid in the same EHV cable trench.

34 OPTICAL FIBRE CABLE (For Communication Equipments)

If specified in the bidding documents, Optical fibre cable required for Communication Equipments shall also be laid in the same cable trench in separate HDPE pipe.
CHAPTER 17: SUBSTATION AUTOMATION SYSTEM

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ANNEXURE-I    LIST OF ANALOGUE AND DIGITAL INPUT
ANNEXURE-II   LIST OF IO POINTS TO BE TRANSMITTED TO RSCC
CHAPTER 17: SUBSTATION AUTOMATION SYSTEM

1.0 GENERAL

1.1. The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system which must be in satisfactory operation on 220kV system or higher for at least 2 (Two) years as on the date of bid opening.

1.2. The Substation Automation System (SAS) shall be installed to control and monitor all the substation equipment from remote control centre (RCC) as well as from local control centre.

The SAS shall contain the following main functional parts:
- Bay control Intelligence Electronic Devices (IEDs) for control and monitoring.
- Station Human Machine Interface (HMI)
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Gateway for remote control via industrial grade hardware (to RCC) through IEC60870-5-101 protocol.
- Gateway for remote supervisory control (to RSCC), the gateway should be able to communicate with RSCC on IEC 60870-5-101 protocol. The specific protocol to be implemented is enclosed as Appendix-I. It shall be the bidder’s responsibility to integrate his offered system with existing RSCC system for exchange of desired data. The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Appendix-II for data exchange with RLDCs.
- Remote HMI.

1.3. Peripheral equipment like printers, display units, key boards, Mouse etc. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

1.4. The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

2.0 System design

1. General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as given in Chapter 1 - GTS.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in Extra high voltage substations, follow the
latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from Remote Control centres via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC panels (described in other sections of technical specifications) housed in air-conditioned Switchyard Panel Room suitably located in switchyard and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building.

2. System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process.

The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in G.I conduit pipes. Data exchange is to be realized using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure.

The communication shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber...
shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers.

At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

3.0 FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

- Remote control centres
- Station HMI.
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time.

The operation shall depend on the conditions of other functions, such as interlocking, synchrocheck, etc. (see description in "Bay level control functions").

3.1 Select-before-execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

3.2 Command supervision

Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

In addition to software interlocking hardwired interlocking are to be provided for:

(a) Bus Earth switch Interlocking
(b) Transfer Bus interlocking (if applicable)

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.
A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

### 3.3 Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

### 3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

### 3.5 User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions

b. System Level Functions

### 3.6 Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions including data collection functionality in bay control/protection unit.
- Bay protection functions

Separate IEDs shall be provided for bay control function and bay protection function.

#### 3.6.1 Bay control functions

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### 3.6.1.1 Overview

#### Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
  - Interlocking and blocking
  - Double command

- Synchrocheck, voltage selection
- Run Time Command cancellation
- Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor runtime supervision
- Operating pressure supervision through digital contacts only
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 200 events
- Extension possibilities with additional I/O’s inside the unit or via fibre-optic communication and process bus

3.6.1.2 Control mode selection

Bay level Operation:
As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation
It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED.

REMOTE mode
Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

3.6.1.3 Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- Settable voltage, phase angle, and frequency difference.
- Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.
- Synchronising between live line and live bus with synchro-check function

Voltage selection
The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.
3.6.1.4 Transformer tap changer control
   Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.6.2 Bay protection functions

3.6.2.1 General
   The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection.

   IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

   **Event and disturbance recording function**
   Each IED should contain an event recorder capable of storing at least 200 time-tagged events. The disturbance recorder function shall be as per detailed in Chapter 15 – Control, Relay & Protection Panels.

3.6.2.2 Bay Monitoring Function:
   Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.7 System level functions

3.7.1 Status supervision
   The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

   The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

   The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

3.7.2 Measurements
   The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The
abnormal values must be discarded. The analogue values shall be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

3.7.3 Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems are enclosed as Annexure-I

3.7.4 Station HMI

3.7.4.1 Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

3.7.4.2 Presentation and dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

- Single-line diagram showing the switchgear status and measured values
- Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked.
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status
3.7.4.3 HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state

3.7.4.4 Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

3.7.4.5 System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.
3.7.4.6 Event list

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with 1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.
- Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

3.7.4.7 Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.
Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

3.7.4.8 Object picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking
- Authority
- Local / remote control
- RSCLC / SAS control
- Errors
- etc.,

shall be displayed.

3.7.4.9 Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and disconnector
- Transformer tap-changer

3.7.5 User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed
The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

3.7.6 Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- Trend reports:
  - Day (mean, peak)
  - Month (mean, peak)
  - Semi-annual (mean, peak)
  - Year (mean, peak)

- Historical reports of selected analogue values:
  - Day (at 15 minutes interval)
  - Week
  - Month
  - Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications along with the current value it interrupts (in both condition i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.

vii. Printout on adjustable time period as well as on demand system frequency and average frequency.
viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

3.7.7 Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

3.7.8 Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

3.7.9 Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.7.10 IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

3.7.11 Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.8 Gateway

3.8.1 Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations.

The Substation Automation System shall have communication ports as follows:
(a) Two ports for Remote Control Centre
(b) Two ports for Regional System Coordination Centre (RSCC)

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer’s control
centres (RCC & RSCC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control centre’s data scan and control commands may be different for different data points within the substation automation system's database.

3.8.2 Remote Control Centre Communication Interface

The Employer will supply communication channels between the Substation Automation System and the remote control centre. The communication channels provided by Employer will consist either of power line carrier, microwave, optical fibre, VSAT or leased line, the details of which shall be provided during detailed Engineering.

3.8.2.1 Interface equipment:

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in Chapter 1 - GTS.

In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder.

3.8.2.2 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc..

4.0 System hardware:

4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Workstation:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade.

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features. The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval) and digital data
including alarm, event and trend data for thirty (30) days,

2. Storage of all necessary software,
3. 20GB space for OWNER’S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.1 HMI (Human Machine Interface)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

4.1.2 Visual Display Units/TFT’s (Thin Film Technology)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21” diagonally in size and capable of colour graphic displays.

The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.3 Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing.

All printers shall be continuously online.

4.1.4 Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit in form of DVD RW. The unit should support at least Read (48X), Write (24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet Filesystems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software.

4.1.5 Switched Ethernet Communication Infrastructure:
The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. One switch shall be provided to connect all IEDs for two bays of 220kV yard to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

4.2 Bay level unit

The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data for at least 24 hours.

One number Bay level unit shall be provided for supervision and control of each 220 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay.

The bay control unit for future bay (if required as per Chapter 1 – Project Specification Requirement) shall be installed in a separate panel.

The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

4.2.1 Input/Output (I/O) modules

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state.
4.3 **Switchyard Panel Room:**

The switchyard panel room shall be constructed to house Bay level units, bay mimic, relay and protection panels, PLCC panels etc. The layout of equipment/panel shall be subject to Owner's approval. The switchyard panel room shall be provided with necessary illuminations, fire alarm system with at least two detectors with necessary power supply if required and it shall be wired to SAS. The detailed constructional requirement of switchyard panel room is detailed in chapter 14 civil of technical specification and air conditioning requirement of switchyard panel room shall be as detailed in chapter 10 Air conditioning system of technical specification. The air conditioner provided in switchyard panel room shall be monitored from substation automation system.

4.4 **Extendibility in future**

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

5.0 **Software structure**

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

5.1.1 **Station level software**

5.1.1.1 **Human-machine interface (HMI)**

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

5.1.2 **Bay level software**

5.1.2.1 **System software**

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the
software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

5.1.2.2 Application software
In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library. The application software within the control/protection devices shall be programmed in a functional block language.

5.1.2.3 Network Management System (NMS):

The contractor shall provide a network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occurs
(d) Provide facility to add and delete addresses and links

The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

6.0 TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

6.1 Type Tests:

6.1.1 Control IEDs and Communication Equipment:

a. Power Input:
   i. Auxiliary Voltage
   ii. Current Circuits
   iii. Voltage Circuits
   iv. Indications

b. Accuracy Tests:
   i. Operational Measurd Values
c. **Insulation Tests:**
   - i. Dielectric Tests
   - ii. Impulse Voltage withstand Test

d. **Influencing Quantities**
   - i. Limits of operation
   - ii. Permissible ripples
   - iii. Interruption of input voltage

e. **Electromagnetic Compatibility Test:**
   - i. 1 MHZ. burst disturbance test
   - ii. Electrostatic Discharge Test
   - iii. Radiated Electromagnetic Field Disturbance Test
   - iv. Electrical Fast transient Disturbance Test
   - v. Conducted Disturbances Tests induced by Radio Frequency Field
   - vi. Magnetic Field Test
   - vii. Emission (Radio interference level) Test.
   - viii. Conducted Interference Test

f. **Function Tests:**
   - i. Indication
   - ii. Commands
   - iii. Measured value Acquisition
   - iv. Display Indications

g. **Environmental tests:**
   - i. Cold Temperature
   - ii. Dry Heat
   - iii. *Wet heat*
   - iv. Humidity (Damp heat Cycle)
   - v. Vibration
   - vi. Bump
   - vii. Shock

6.2 **Factory Acceptance Tests:**

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED’s applicable type test certificates shall be submitted.

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Substation Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

If the complete system consists of parts from various suppliers or some parts
are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

6.2.1 Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

6.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

6.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

7.0 SYSTEM OPERATION

7.1 Substation Operation

7.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI (Human Machine interface) subsystem consisting of graphic colour VDU, a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields:

i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different
meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and
- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

8.0 POWER SUPPLY

Power for the substation automation system shall be derived from substation 220V DC system.
2No.s of Inverter of minimum 2KVA capacity shall be provided for servers, gateways station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. Inverter shall be connected to 220V DC independent source and should be used to drive 1No. each server/HMI/Gateway so that in case any failure of DC power supply system is not affected.

9.0 DOCUMENTATION

The following documents shall be submitted for employer’s approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Functional Design Document
(d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be
provide in “dxf“ format.

- List of Drawings
- Substation automation system architecture
- Block Diagram
- Guaranteed technical parameters, Functional Design Specification and
  Guaranteed availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels
- Logic Diagram (hardware & software )
- Switchyard Panel Room layout drawing
- Control Room Lay-out
- Test Specification for Factory Acceptance Test (FAT)
- Product Manuals
- Assembly Drawing
- Operator’s Manual
- Complete documentation of implemented protocols between various
  elements
- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built
documents/drawings shall be provided.

10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 Training
Contractor personnel who are experienced instructors and who speak
understandable English shall conduct training. The contractor shall arrange on
its own cost all hardware training platform required for successful training and
understanding in Nepal. The Contractor shall provide all necessary training
material. Each trainee shall receive individual copies of all technical manuals
and all other documents used for training. These materials shall be sent to
Employer at least two months before the scheduled commencement of the
particular training course. Class materials, including the documents sent
before the training courses as well as class handouts, shall become the
property of Employer. Employer reserves the right to copy such materials, but
for in-house training and use only. Hands-on training shall utilize equipment
identical to that being supplied to Employer.

The Contractor shall quote training prices as indicated in BPS.

The schedule, location, and detailed contents of each course will be finalized
during Employer and Contractor discussions.

10.2 Computer System Hardware Course
A computer system hardware course shall be offered, but at the system level
only. The training course shall be designed to give Employer hardware
personnel sufficient knowledge of the overall design and operation of the
system so that they can correct obvious problems, configure the hardware,
perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) **System Hardware Overview**: Configuration of the system hardware.
(b) **Equipment Maintenance**: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.
(c) **System Expansion**: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
(d) **System Maintenance**: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
(e) **Subsystem Maintenance**: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.
(f) **Operational Training**: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

10.3 **Computer System Software Course**

The Contractor shall provide a computer system software course that covers the following subjects:

(a) **System Programming**: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.
(b) **Operating System**: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures
(c) **System Initialization and Failover**: Including design, theory of operation, and practice
(d) **Diagnostics**: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,
(e) **Software Documentation**: Orientation in the organization and use of system software documentation.
(f) **Hands-on Training**: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.4 **Application Software Course**

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course.
The training shall include:

(a) **Overview:** Block diagrams of the application software and data flows. Programming standards and program interface conventions.

(b) **Application Functions:** Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.

(c) **Software Development:** Techniques and conventions to be used for the preparation and integration of new software functions.

(d) **Software Generation:** Generation of application software from source code and associated software configuration control procedures.

(e) **Software Documentation:** Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.

(f) **Hands-on Training:** One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

### 10.5 Requirement of training:
The contractor shall provide training for OWNER'S personnel comprehensively covering following courses.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of Course</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Computer System Hardware</td>
</tr>
<tr>
<td>2</td>
<td>Computer System Software</td>
</tr>
<tr>
<td>3</td>
<td>Application Software</td>
</tr>
</tbody>
</table>

### 11.0 Maintenance

#### 11.1 Maintenance Responsibility during the Guaranteed Availability Period.

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. **During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.**

### 12.0 RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electromagnetic interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security requirements
  - Process know-how
  - Select before execute at operation
  - Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potential rise

Outage terms
1) Outage
   The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) Actual outage duration (AOD)
   The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest 1/4th of an hour. Time less than 1/4th of an hour shall be counted as having duration of 1/4th of an hour.

3) Period Hours (PH)
   The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

4) Actual Outage hours (AOH)
   The sum of actual outage duration within the reporting period
   \[ \text{AOH} = \sum \text{AOD} \]

5) Availability:
   Each SAS shall have a total availability of 99.98% i.e. the ratio of total time duration minus the actual outage duration to total time duration.

12.1 Guarantees Required
   The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.
The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

13.0 Spares

13.1 Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

13.2 Availability Spares:

In addition to mandatory spares as listed in section project for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

14.0 LIST OF EQUIPMENTS

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

i) Station HMI
ii) Redundant Station HMI (in Hot-stand by mode)
iii) Bay level units along with bay mimic as detailed in Chapter 1 – Project Specification Requirement.
iv) Bay Level Unit for Auxilliary system (as per requirement)
v) Disturbance Recorder Work Station(Maintenance HMI)
vi) Colour Laser Printer – 1 No. (For Reports & Disturbance records)
vii) Dot matrix printers - (one each for Alarms and log sheets)
viii) All interface equipment for gateway to RCC and RSCC
ix) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
x) Remote workstation including HMI and along with one printer
xi) Modems as per requirement.

xii) Any other equipment as necessary
List of Analogue and Digital Inputs

Basic Monitoring requirements are:
- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformers & reactors
- Ambient temperature
- Status and display of 400V LT system, 220V & 48V DC system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in PLCC panels through potential free contacts from PLCC or independently by counting the receive/send commands.
- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Transformer

List of Inputs

The list of input for typical bays is as below:-

Analogue inputs

i) For line
   Current: R phase, Y phase, B phase
   Voltage: R-Y phase, Y-B phase, B-R phase

ii) For transformer/reactor
    Current: R phase, Y phase, B phase
    WTI (for transformer and reactor)
    Tap position (for transformer only)

iii) For TBC and bus coupler
    Current: R phase, Y phase, B phase

iv) Common
a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable

<table>
<thead>
<tr>
<th>Voltage</th>
<th>R-Y phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y-B phase</td>
</tr>
<tr>
<td></td>
<td>B-R phase</td>
</tr>
</tbody>
</table>

b) Frequency for Bus-I and Bus-II

c) Ambient temperature (switchyard)
d) **Switchyard Panel Room Temperature.**
e) **LT system**

   i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
   ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
   iii) Voltage R-Y, Y-B, B-R of Diesel Generator
   iv) Current from LT transformer-I
   v) Current from LT transformer-II
   vi) Current from Diesel Generator
   vii) Voltage of 220V DCDB-I
   viii) Voltage of 220V DCDB-II
   ix) Current from 220V Battery set-I
   x) Current from 220V Battery set-II
   xi) Current from 220V Battery charger-I
   xii) Current from 220V Battery charger-II
   xiii) Voltage of 48V DCDB-I
   xiv) Voltage of 48V DCDB-II
   xv) Current from 48V Battery set-I
   xvi) Current from 48V Battery set-II
   xvii) Current from 48V Battery charger-I
   xviii) Current from 48V Battery charger-II

d) **Digital Inputs**

The list of input for various bays/SYSTEM is as follows:

1. **Line bays**

   i) Status of each pole of CB.
   ii) Status of Isolator, Earth switch
   iii) CB trouble
   iv) CB operation/closing lockout
   v) Pole discrepancy optd
   vi) Trip coil faulty
   vii) LBB optd
   viii) Bus bar protn trip relay optd
   ix) Main bkr auto recloser operated
   x) Tie/transfer auto recloser operated
   xi) A/r lockout
   xii) Tie/transfer bkr a/r lockout
   xiii) Direct trip-I/II sent
   xiv) Direct trip-I/II received
   xv) Main I/II blocking
   xvi) Main I/II-Inter trip send
   xvii) Main I/II-Inter trip received
   xviii) O/V STAGE – I operated
   xix) O/V STAGE – II operated
   xx) FAULT LOCATOR FAULTY
   xi) MAIN-I/II CVT FUSE FAIL
   xii) MAIN-I PROTN TRIP
   xiii) MAIN-II PROTN TRIP
   xiv) MAIN-I PSB ALARM
xxv) MAIN-I SOTF TRIP
xxvi) MAIN-I R-PH TRIP
xxvii) MAIN-I Y-PH TRIP
xxviii) MAIN-I B-PH TRIP
xxix) MAIN-I START
xxx) MAIN-I/II Carrier aided trip
xxxi) MAIN-I/II fault in reverse direction
xxxii) MAIN-I/II ZONE-2 TRIP
xxxiii) MAIN-I/II ZONE-3 TRIP
xxxiv) MAIN-I/II weak end infeed optd
xxxv) MAIN-II PSB alarm
xxxvi) MAIN-II SOTF TRIP
xxxvii) MAIN-II R-PH TRIP
xxxviii) MAIN-II Y-PH TRIP
xxxix) MAIN-II B-PH TRIP
xl) MAIN-II start
xli) MAIN-II aided trip
xlii) MAIN-I/II fault in reverse direction
xliii) Back-up o/c optd
xliv) Back-up e/f optd
xlv) 220V DC-I/II source fail
xlvi) SPEECH CHANNEL FAIL
xlvii) PLCC Protection Channel-I FAIL
xlviii) PLCC Protection Channel-II FAIL

2. Transformer bays

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
_ix) DIF OPTD
x) OVERFLUX ALARM (MV)
xi) OVERFLUX TRIP (MV)
 xii) OVERFLUX ALARM (HV)
 xiii) OVERFLUX TRIP (HV)
 xiv) HV BUS CVT ½ FUSE FAIL
 xv) MV BUS CVT ½ FUSE FAIL
 xvi) OTI ALARM/TRIP
 xvii) PRD OPTD
 xviii) OVERLOAD ALARM
 xix) BUCHOLZ TRIP
 xx) BUCHOLZ ALARM
 xxi) OLTC BUCHOLZ ALARM
 xxii) OLTC BUCHOLZ TRIP
 xxiii) OIL LOW ALARM
 xxiv) back-up o/c (HV) optd
 xxv) back-up e/f (HV)optd
 xxvi) 220v DC-I/II source fail
 xxvii) TAP MISMATCH
 xxviii) GR-A PROTN OPTD
 xxix) GR-B PROTN OPTD
 xxx) back-up o/c (MV) optd
 xxxi) back-up e/f (MV)optd
3. Transformer bays

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) HV BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220v DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

4. Line/Bus Reactor bays (as applicable):

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) Line/ BUS CVT ½ FUSE FAIL
xi) OTI ALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220V DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

5. Bus bar Protection

i) Bus bar main-I trip
ii) Bus bar main-II trip
iii) Bus bar zone-I CT open
iv) Bus bar zone-II CT open
v) Bus transfer CT sup. Optd
vi) Bus transfer bus bar protn optd
vii) Bus protection relay fail

6. Auxiliary system

i) Incomer-I On/Off
ii) Incomer-II On/Off
7. Switchyard Panel Room:

i) AC Compressor 1 ON/OFF  
ii) AC Compressor 2 ON/OFF  
iii) Fire Detection 1 ON/OFF  
iv) Fire Detection 2 ON/OFF  
v) Switchyard Panel Room Temperature High Alarm

The exact number and description of digital inputs shall be as per detailed engineering requirement. Apart from the above mentioned digital inputs, minimum of 200 inputs shall be kept for future use.
Note:

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-5-101 protocol.
4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.
5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.
List of IO Points to be transmitted to RSCC

a) MW and MVAR for all lines, transformers, reactors and Capacitors
b) Voltage of all buses
c) Frequency of 220kV Bus
d) All Breakers
e) All isolators
f) Tap Position for all transformers
g) Master protection signal for all feeders, transformers Units and Bus Bar
h) Loss of Voltage signal for Bus bar
i) All the points identified in point (e), (h) and (i) above as GPS Time stamped.
j) Temperature value per substation.
k) Any other point decided during detailed engineering
TECHNICAL SPECIFICATIONS

FOR

FIBRE OPTIC BASED COMMUNICATION EQUIPMENTS

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FIBRE OPTICS BASED COMMUNICATION EQUIPMENTS

SECTION-1

INTRODUCTION, GENERAL INFORMATION AND GENERAL REQUIREMENT

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FIBRE OPTICS BASED COMMUNICATION EQUIPMENTS

SECTION-1

This document describes the technical specifications for Communication Equipment which includes Fibre Optic Terminal Equipment and Multiplexer Equipments for Establishment of Fibre Optic Communication System under the contract. This specification describes the functional and performance requirements of the system.

1.1 Scope and General Requirements

The broad scope of the procurement of this part include the survey, planning, design, engineering, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, termination, testing, training, and demonstration for acceptance, commissioning and documentation for:

(i) SDH Equipment along with suitable optical line interfaces & tributary cards.
(ii) Associated Termination equipment (Drop-insert multiplexers, subscriber line interfacing card etc.)
(iii) Local Craft Terminal
(iv) All cabling, wiring, Digital Distribution Frame patch facilities, equipment MDF’s and interconnections to the supplied equipment at the defined interfaces.
(v) MDF & DDF cross connects required to route and activate circuits.
(vi) System integration of the supplied subsystems and also integration with existing communication equipment such as SDH, MUX etc.
(vii) System integration of the supplied equipments (termination equipment system) with existing equipments for seamless transmission of communication channel
(viii) Integration of supplied system with the User equipments such as RTUs, SCADA system, PLCC equipment, PABX etc.
(ix) Maintenance of the supplied system

All other associated works/items described in the technical specifications for a viable and fully functional communication network.

1.2 General Requirements

The Contractor is encouraged to offer standard products and designs. However, the Contractor must conform to the requirements and provide any special equipment necessary to meet the requirements stated herein.

It should be noted that preliminary design information and bill of quantity (BoQ) specified in this specifications are indicative only. The Contractor shall verify the design data during the site surveys & detail engineering and finalise the BoQ as required for ultimate design & system performance.

The Bidder’s proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without further necessity for inquiries.

An analysis of the functional and performance requirements of this specification and/or site surveys, design, and engineering may lead the Contractor to conclude that additional items are required that are not specifically mentioned in this specification. The Contractor shall be
responsible for providing at no added cost to the Employer, all such additional items and services such that a viable and fully functional communication equipment system is implemented that meets or exceeds the capacity, and performance requirements specified. Such materials and services shall be considered to be within the scope of the contract. To the extent possible, the Bidders shall identify and include all such additional items and services in their proposal.

All equipment provided shall be designed to interface with existing equipment and shall be capable of supporting all present requirements and spare capacity requirement identified in this specification.

The communication equipment shall be designed and provisioned for expansions and reconfigurations without impairing normal operation, including adding and removing circuits. The offered items shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

The Bidders are advised to visit sites (at their own expense), prior to the submission of a proposal, and make surveys and assessments as deemed necessary for proposal submission. The successful bidder (Contractor) is required to visit all sites. The site visits after contract award shall include all necessary surveys to allow the contractor to perform the design and implementation functions. The Contractor shall inform their site survey schedule to the Employer well in advance. The site survey schedule shall be finalised in consultation with the Employer. The Employer may be associated with the Contractor during their site survey activities.

After the site survey, the Contractor shall submit to the Employer a survey report on each link and site. This report shall include at least the following items:

(a) Proposed layout of Equipment in the existing rooms and buildings.
(b) Proposed routing of power, earthing, signal cables and patch cords etc.
(c) Confirmation of adequacy of Space and AC/DC Power supply requirements
(d) Proposals for new rooms/buildings if required
(e) Identification of facility modifications if required
(f) Identify all additional items required for integration for each site/location.

1.2.1 Synchronization of the Communication Network

The Contractor shall be responsible for synchronization of new communication equipment with existing network utilizing the existing clock (if available). The Contractor shall make an assessment of additional clock requirement for synchronization of the communication equipment.

1.3 General Responsibilities and Obligations

This section describes the general responsibilities and obligations of the Contractor and the Employer.

1.3.1 Responsibilities for the Implementation Plan

The Bidder’s technical proposal shall include a project implementation plan and schedule that is consistent with the implementation plan detailed in this specification. The implementation plan shall be modelled such that it provides fibre optic cabling system support for the activation of this Project. The Implementation plan shall include the activities of both the Contractor and the Employer, showing all key milestones and clearly identifying the nature of all information and project support expected from the Employer. The Employer and Contractor shall finalise the detailed Implementation plan following award of the contract.
1.3.2 Contractor's Responsibilities and Obligations

The Contractor shall be responsible for all cables and wiring associated with the equipment provided, both inside and outside buildings in accordance with technical specifications. The Contractor shall also be responsible for determining the adequacy of the local power source for the equipment and for wiring to it, with adequate circuit protective breakers. In addition, the Contractor shall be responsible for shielding equipment and cabling to eliminate potential interference to or from the equipment, and for earthing all cabinets and shields.

Contractor's obligations include, but are not limited to, the following:

1. Site visits, and surveys, necessary to identify and provide all equipment needed to implementation the network.
2. Equipment Engineering and design specific to each location including review of, and conformance with local environmental and earthing considerations.
3. Overall integration of communication equipments/subsystem procured in present and existing network.
4. All cabling, wiring including supply, laying and termination etc of the cables, and distribution frame at wideband nodes required for full interconnectivity and proper operation of the telecommunications network including equipment supplied under this package and the connectivity and interfacing of user equipment.
5. Installation and integration of network management software, hardware and firmware (as applicable).
6. Project management, project scheduling, including periodic project reports documenting progress, review meeting during the contract period.
7. Engineering and technical assistance during the contract and warranty period.
8. Implement all minor civil works and identify any major civil works i.e. expansion or construction of rooms, trenches necessary for installation of proposed equipment and provide the details of such work to the Employer.
9. Factory and site testing of all hardware, software, and firmware provided.
10. Provide documented evidence of satisfactory Type Test performance to the Employer and if required by The Employer, conduct type test.
11. Provide a Quality Assurance Plan, ensuring the Employer access to the manufacturing process.
12. Training of the Employer personnel.
13. Hardware, software, and firmware maintenance, debugging, and support of the equipment through final acceptance, and maintenance on all new equipment through out the warranty period and for a period of six (6) years after warranty period.
14. Availability of service, spare and expansion parts for the supplied items for the designed life of the equipment or seven (7) years after the declaration of withdrawal of equipment from production, whichever is earlier. However, the
termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

Detailed descriptions of the Contractor's obligations, in relation to individual items and services offered, are delineated in other sections of this specification.

1.3.3 The Employer Responsibilities and Obligations

The Employer will provide the following items and services as part of this Project:

(1) Overall project management of the project
(2) Review and approval of the Contractor's designs, drawings, and recommendations.
(3) Communication network configuration data, including:
   (a) Channel assignments for voice and data
   (b) Interconnection drawings for existing equipment
(4) Review and approval of test procedures.
(5) Participation in and approval of "Type", factory and site acceptance tests where testing is required.
(6) Review and approval of training plans.
(7) Providing support and access to facilities at the sites.
(8) Implement the major civil works such as expansions or construction of rooms, trenches etc. as required for the equipment to be provided by the Contractor.
(9) Coordination of the Contractor's activities with the Employer's and constituents' concerned departments.
(10) Provide to the extent possible drawings for existing sites and facilities for which equipment installations are planned.
(11) Approval of the key personnel for the project

1.4 Applicable Standards

The following standards and codes shall be generally applicable to the equipment and works supplied under this Contract:

(i) IEEE 802.3
(iv) ITU-T/CCITT Recommendations of the V Series
(v) ITU-T/CCITT Recommendations R35, R37, and R38A (or R38B)
(vi) ITU-T/CCITT Recommendations M3010, G771
(vii) Internet Activities Board, RFC-1157 (SNMP)
(ix) International Electrotechnical Commission standards, IEC 1000-4-xx series.
(xii) International CISPR standards

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full
salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.
FIBRE OPTIC BASED COMMUNICATION EQUIPMENTS

SECTION 2

NETWORK CONFIGURATION AND EQUIPMENT CHARACTERISTICS

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FIBRE OPTIC BASED COMMUNICATION EQUIPMENTS

SECTION 2

NETWORK CONFIGURATION AND EQUIPMENT CHARACTERISTICS

2.1 Introduction

This section describes the Fibre Optic Communication network configuration and the equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

(1) Fibre Optic Transmission System (FOTS)
(2) Termination Equipment Subsystems
(3) MDF, DDF and Cabling

The requirements described herein are applicable to and in support of network requirements. The equipment supplied shall support existing network for Power system operational requirements.

The security related requirements of the equipment shall be as per relevant agency and shall be followed/complied by the vendor.

The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility and supply chain and subject all software to a security/threat check any time during the supplies of equipment.

The contractor shall ensure that the supplied equipments have been got tested as per relevant contemporary International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards until 31st March 2013. From 1st April, 2013, the certification shall be got done from authorized and certified agency.

The Contractor shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipments, software etc. supplied and implemented in the project shall be given for use by the Employer.

In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability and criminal proceedings can be initiated against the Contractor as per guidelines of Government department.

2.2 General Network Characteristics

2.2.1 Description

The fibre optic network shall be based on the Synchronous Digital Hierarchy (SDH) having bit rate of STM-4 (upto 3 MSP protected directions) as indentified in the BoQ. The network shall consist of overhead fibre optic links with a minimum bit rate of Synchronous Transport Module-4 (STM-4). The Contractor can propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any
other specification requirement. The detailed BOQ is described in appendices.

2.2.2 Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS/RTUs/PMUs. The communications support requirement for SCADA/EMS/RTUs/PMUs system is for low & high speed data, express voice circuits and administrative voice circuits as defined in appendices. A brief summary of the communication system requirements is as follows:

(a) High speed E1 channel support
(b) 64kbps & nx64kbps data channel support
(c) Low speed (300 -1200 bps) data channel support
(d) Voice (2 wires, 4 wires) channel support.
(e) Data transport supporting Network Management channels
(f) The connectivity envisaged between RTUs and Control Centre over TCP-IP using Ethernet interface or over serial interface.

2.2.3 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

2.2.3.1 System Synchronization

The Contractor shall synchronize the existing equipments and all the new equipments under the contract using existing Master clock, if available. The Contractor shall provide the additional clocks as required under the set of clock indicated in BoQ. In addition to GPS input reference, the synchronization clock must have provision to take INPUT reference coming from other clock. The contractor shall submit the synchronisation plan as per standard ITU-T G.811. All sync equipments proposed under this contract should meet ITU-T G.811 criterion. The holdover quality of slave clock, if any, shall meet ITU-T G.812 standard requirements.

The Contractor shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipments new & existing. The Contractor shall submit the synchronization plan for the entire network meeting the requirement of ITU-T G.803. The synchronization plan shall clearly indicate the requirement of additional clocks with full justification.

The system equipment requiring “clock” shall be connected to the master clock using external clocking. For this purpose, appropriate interfaces(s) in the transmission & termination equipment being supplied and all other associated hardware shall be provided by the Contractor.

2.2.3.2 System Maintainability

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from
remote locations, manually and/or initiated under TMN control (if provided). Such testing shall not affect the functional operation of the system.

2.2.3.3 System Upgradeability and Expandability

Equipment supplied shall be sized (though not necessarily equipped) to support system/subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for equipped subunits shall be terminated at appropriate patching facilities or termination blocks. Power supplies shall be sized for maximum equipped system capacity.

2.2.3.4 Equipment Availability

The calculated availability of each fibre optic link (E1 to E1) shall be at least 99.999%. The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the mean-time-to-repair (MTTR) of the components and subsystems comprising the FOTS. For this analysis, an MTTR of at least 4 hours shall be assumed. The down time of the fibre optic cable shall not be considered in the aforesaid availability calculations. The calculated failure rates of the units and the calculated availabilities of the equipment being offered shall be provided by the Contractor during detailed engineering.

2.2.3.5 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most of current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests or under special circumstances, on written approval by Employer, prior to the completion of SAT.

2.2.3.6 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BoQ and configuration requirements as identified in the appendices. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion.

2.2.3.7 Redundancy Requirements and Protection Schemes

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 2-1. The failure of one element shall not prevent the use of any other that has not failed.

<table>
<thead>
<tr>
<th>Table 2-1</th>
<th>Equipment Redundancy Requirements Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fiber Optic transmission Equipment :</strong></td>
<td>1:1 APS or distributed power supply</td>
</tr>
<tr>
<td>SDH equipment</td>
<td>1:1 APS</td>
</tr>
</tbody>
</table>
Table 2-1
Equipment Redundancy Requirements Summary

<table>
<thead>
<tr>
<th>MUX, DROP/INSERT Power Supply</th>
<th>1:1 APS or distributed power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>* = Common control cards which are essentially required for operation of the equipment.</td>
<td></td>
</tr>
</tbody>
</table>

The offered equipment shall support at least SNCP as per standard ITU-T G.841. In case the equipment offered by the Bidder does not support the above mentioned minimum protection methods, the bidder shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost to Employer. The bidders shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

2.2.3.8 Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

2.2.3.9 Software Upgrades

The Contractor shall provide antivirus software along with all the computer hardware/software which shall be upgraded periodically till the maintenance services contract in the bid. Further, to meet all the specifications requirements during implementation and maintenance, if upgrade in the hardware/software of supplied item is required, the same shall be done by the contractor without any additional cost to the Employer.

2.2.3.10 General Site Considerations

All fiber optic links up to 175 kms transmission line length shall be implemented by the Contractor without repeaters. In order to meet the link budget requirement, the Contractor shall provide all the necessary equipments only in the end stations. The contractor may provide the optical amplifier, wave length translator, optical cards or high capacity SDH equipment with suitable rack/subrack to meet the maximum distance limit. All the provided equipments shall be monitored/managed by Craft Terminal.

2.2.3.11 Proposed Optical Fibre Characteristics

The link budget calculations and equipment design shall be based on the specified fibre parameters. The optical cables shall have Dual Window Single Mode (DWSM) fibres conforming to ITU-T Recommendations G.652D and the major parameters of these optical fibre(s) are defined in Table-2-2:
Table-2-2  
Optical Fibre Characteristics

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre Description</td>
<td>Dual-Window Single-Mode (DWSM)</td>
</tr>
<tr>
<td>Mode Field Diameter</td>
<td>8.6 to 9.5 μm (±0.6 μm)</td>
</tr>
<tr>
<td>Cladding Diameter</td>
<td>125.0 μm ± 1μm</td>
</tr>
<tr>
<td>Mode field Concentricity Error</td>
<td>≤ 0.6μm</td>
</tr>
<tr>
<td>Core-Clad concentricity error</td>
<td>≤ 1.0μm</td>
</tr>
<tr>
<td>Cladding non-circularity</td>
<td>≤ 1%</td>
</tr>
<tr>
<td>Cable Cut off Wavelength</td>
<td>≤ 1260 nm</td>
</tr>
<tr>
<td>1550 loss performance</td>
<td>As per G.652D</td>
</tr>
<tr>
<td>Proof Test Level</td>
<td>≥ 0.69 Gpa</td>
</tr>
<tr>
<td>Attenuation coefficient</td>
<td>@1310 nm ≤ 0.35 dB/Km</td>
</tr>
<tr>
<td>Attenuation variation with wavelength</td>
<td>@1550 nm ≤ 0.21 dB/Km</td>
</tr>
<tr>
<td>Thermal stability</td>
<td></td>
</tr>
<tr>
<td>Chromatic Dispersion; Max.</td>
<td>18.0 ps/(nm x km) @ 1550 nm</td>
</tr>
<tr>
<td>Zero Dispersion Wavelength</td>
<td>3.5 ps/(nm x km) @ 1288-1339nm</td>
</tr>
<tr>
<td>Zero Dispersion Slope</td>
<td>5.3 ps/(nm x km) @ 1271-1360nm</td>
</tr>
<tr>
<td>Polarization mode dispersion coefficient</td>
<td>≤ 0.2 ps/km(^{1/2})</td>
</tr>
<tr>
<td>Temperature Dependence</td>
<td>Induced attenuation ≤ 0.05 dB (-60 deg C - +85 deg C)</td>
</tr>
<tr>
<td>Bend performance</td>
<td>@1310nm (75±2 mm dia Mandrel), 100 turns; Attenuation rise ≤ 0.05 dB @1550nm (30±1 mm dia Mandrel), 100 turns; Attenuation rise ≤ 0.10 dB @1550nm (32±0.5 mm dia Mandrel), 1 turn; Attenuation rise ≤ 0.50 dB</td>
</tr>
<tr>
<td>Bend performance</td>
<td></td>
</tr>
</tbody>
</table>

2.2.5 Fibre Optic Link Lengths

The fiber optic route lengths are as specified in appendices. The lengths specified in appendices are the transmission line route lengths; however the actual fiber cable length shall exceed the route lengths on account of extra cable requirement due to sag, jointing & splicing, approach cabling etc. For bidding purposes the Contractor may assume an
additional cable length of 5% of given route length + 1Km towards approach cable for calculating the link length. The exact cable lengths shall be determined by the Contractor during the survey. The same shall be used by the Contractor for final link design during the detailed engineering of the project.

2.3 **Fibre Optic Transmission System**

The Fibre Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. Minimum aggregate bit rate shall be STM-4 (upto 3 MSP protected directions) and equipped with 1 nos. of minimum 16 port E1 interface(G.703) card, two no. of minimum 4 port Ethernet interface (IEEE 802.3/IEEE 802.3u) card supporting layer 2 switching as tributaries. The Ethernet interfaces shall support VLAN (IEEE 802.1P/Q), spanning tree (IEEE 802.1D) quality of service. Protection scheme for Ethernet traffic should be ERPS based (Ethernet ring protection scheme) as per ITU-T G.8032.

The Contractor shall provide (supply and install) connectorised jumpers (patch cords) for FODP-to-equipment and equipment-to-equipment connection. Two number spare jumpers shall be provided for each equipment connection. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

2.3.1 **SDH Equipment**

2.3.1.1 **Functional Requirement**

There is a requirement for different types of equipment under this project which are described in this section. The BOQ is provided in the appendices. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary Cards (Electrical tributaries such as E1 & Ethernet 10/100 Mbps) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub-rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).

If bidder is offering equipment with multifunction cards such as cross-connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements of the specifications. Further, main and protection channel shall be terminated on separate cards and there shall not be single point of failure.

The equipment shall be configurable either as Terminal Multiplexer (TM) as well as ADM with software settings only.

**SDH ADM**

The aggregate interfaces shall be (at least) STM-4 towards at least two protected directions (Protected as specified in this specifications). At present the equipment shall be equipped with a 1 nos., min.16 E-1 port electrical tributary cards & two no., min.4 port Ethernet interface card as tributaries. The equipment shall provide access to full STM-4 payload.
The offered STM-4 SDH equipment shall be upgradable to STM-4 by changing optical line cards only. Cross connection (VC4) capability of offered SDH equipment shall be provided according to STM-4 equipment. The contractor shall demonstrate the STM-4 capability during FAT.

2.3.1.2 Redundancy and Protection

Two fibre rings shall be implemented wherever the network permits. On linear sections of the network, protected links using 4 fibres shall be implemented.

2.3.1.3 Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Modems that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and one data channel. Both omnibus and selective calling facilities shall be provided. There shall be a facility to extend the line system order-wire to any other system or exchange lines on 2W/4W basis.

2.3.1.4 Supervision and Alarms

ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784. Additionally, F2/Q2 interfaces for a local craftsperson terminal interface and remote equipment monitoring is required. The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station associated devices by the TMN.

2.3.1.5 Synchronisation

The equipment shall provide synchronisation as per Table 2-3. One 2MHz synchronisation output from each equipment shall be provided.

2.3.1.6 Electrical and Optical I/O Characteristics and General Parameters

Table 2-3 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

<table>
<thead>
<tr>
<th>Table 2-3</th>
<th>Electrical and Optical I/O Characteristics and General Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optical Wavelength</strong></td>
<td>1310/1550nm</td>
</tr>
<tr>
<td><strong>Optical Source</strong></td>
<td>Laser</td>
</tr>
<tr>
<td><strong>Optical Source Lifespan</strong></td>
<td>Better than 5 X10⁵ hours</td>
</tr>
<tr>
<td><strong>Optical Fibre Type</strong></td>
<td>G.652 D</td>
</tr>
<tr>
<td><strong>Optical Connectors</strong></td>
<td>Type FC-PC</td>
</tr>
<tr>
<td><strong>Transmission Quality</strong></td>
<td>Per ITU-T G.821, G.823, G.826</td>
</tr>
<tr>
<td><strong>Source Primary Power</strong></td>
<td>-48 Vdc</td>
</tr>
<tr>
<td><strong>Equipment Specifications</strong></td>
<td>Per ITU-T G.783</td>
</tr>
<tr>
<td><strong>Tributary, Electrical Interface</strong></td>
<td>Per ITU-T G.703, 75 Ω</td>
</tr>
</tbody>
</table>
### Ethernet Interface
- 10/100 Mbps

### SDH Bit Rates
- Per ITU-T G.703

### Optical Interfaces
- Per ITU-T G.957, G.958

### Frame and Multiplexing Structure for SDH
- Per ITU-T G.707

### Synchronization
- Per ITU-T G.813

### Management Functions
- Per ITU-T G.774, G.784

### Protection Architectures
- Per ITU-T G.841

### Built In Testing and Alarms
- Per ITU-T G.774, G.783, G.784

**NOTE (1)** Optical wavelength shall be selected considering the characteristics of the optical fibre and the link budget.

**NOTE (2)** **Eye Safety for Laser Equipment**: To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

**NOTE (3)** In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector are to be provided to connect with FODP.

### 2.3.2 Optical Link Performance Requirements

The optical fibre link performance requirements are specified as follows:

#### 2.3.2.1 Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

1. **Fibre attenuation**: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.

2. **Splice loss**: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.

3. **Connector losses**: Losses due to connectors shall be considered to be minimum 1.0 dB per link.

4. **Equipment Parameters**: The equipment parameters to be considered for link budget calculations shall be the guaranteed “End of Life (EOL)” parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.

5. **Optical path Penalty**: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

6. **Maintenance Margin**: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.
(7) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

(8) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibres.

(9) Bit Error Rate: The link budget calculations shall be done for a BER of $10^{-10}$.

The bidders shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fibre optic link during detailed engineering. For finalising the FOTS system design & BOQ, above methodology shall be adopted taking into account fibre attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

2.3.2.2 Link Performance

The Link performance for ES, SES and BER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826.

2.3.2.3 FODP to SDH Equipment

The Contractor shall be responsible for connectivity between the FODP and the SDH equipment. The Contractor shall provide FC PC coupled patch cords. The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

2.4 Termination Equipment Subsystem

The Termination Equipment Subsystem is defined to include the equipment that interfaces (adapts) the subscriber (user) to the Fibre Optic Transmission System (FOTS). A Functional description of these equipments are as follows:

2.4.1 Functional Description

The transmission network node provides subscriber interface to the transmission network and/or switching/routing. For clarity, the basic functions accomplished at the network nodal points, are described briefly as follows:

Primary Multiplexer shall be used to accomplish subscriber connectivity to the Digital Communication Network. Subscriber Line Units shall provide analog to digital and direct digital conversion to 64 Kbps digital channel. In the CEPT standard hierarchy, thirty (30) such 64 Kbps digital channels shall be Time Division Multiplexed (TDM) resulting in a single 2.048 Mbps (E-1) digital bit stream.

Digital Drop-Insert and Branching Equipment shall be used to digitally interface a small number of channels at spur locations without requiring successive D/A and A/D conversions of the throughput channels.

The equipment shall also have an interface for external 2048 kHz synchronisation signal according to ITU-T Recommendation G.703.
2.4.2 First Order (Primary) Multiplexing

The Contractor shall be required to provide E-1 Drop & Insert Multiplexer and E-1 Channel Bank primary multiplexing in compliance with the electrical input-output characteristics provided in Table 2-4.

2.4.2.1 Drop & Insert Primary Multiplexing

Drop & Insert primary multiplexing in conformance with CEPT E-1 characteristics shall be required at locations where the subscriber requirement is minimal. The drop and insertion of up to thirty 64 Kbps channels supporting subscriber line units (SLU) shall be required at intermediate locations. The Drop & Insert Muxes supplied shall be performance and card compatible with the Channel Bank Equipment provided so that all Subscriber Line Interface cards are interchangeable.

Table 2-4
CEPT E-1 Standard First Order Multiplexing

<table>
<thead>
<tr>
<th>Applicable Standards:</th>
<th>CEPT per CCITT Recommendation G.702, G.703, G.711 and G.712</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Tributaries:</td>
<td>30 X 64 Kbps</td>
</tr>
<tr>
<td>Alternative Sub-rate Tributaries:</td>
<td>n X 64 Kbps V.36 64Kb/s V.11/V.36</td>
</tr>
<tr>
<td>Output Aggregate Rate:</td>
<td>2.048 Mb/s ± 50 ppm</td>
</tr>
<tr>
<td>Interface Code:</td>
<td>HDB3</td>
</tr>
<tr>
<td>Impedance:</td>
<td>75 ohm unbalanced</td>
</tr>
<tr>
<td>Peak Level @ 120 ohm:</td>
<td>3.0 volts ± 10%</td>
</tr>
<tr>
<td>Peak Level @ 75 ohm:</td>
<td>2.37 volts ± 10%</td>
</tr>
<tr>
<td>Maximum Insertion Loss:</td>
<td>6 dB</td>
</tr>
<tr>
<td>Signal Waveform:</td>
<td>Per CCITT G.703</td>
</tr>
<tr>
<td>Frame Structure:</td>
<td>Per CCITT G.742</td>
</tr>
<tr>
<td>Jitter Performance:</td>
<td>Per CCITT G.823</td>
</tr>
<tr>
<td>Power Supply Voltage:</td>
<td>-48 Vdc</td>
</tr>
</tbody>
</table>

2.4.2.2 Channel Banks (Mux, Drop/Insert)

User voice and data equipment interfacing requirements are defined at the subscriber line level. Primary multiplexing in conformance with CEPT E-1 characteristics shall be used to provide first order multiplexing of up to thirty 64 Kbps channels supporting Subscriber Line Units (SLUs).

2.4.2.3 Subscriber Line Units/Subscriber Line Interface Cards

The terms Subscriber Line Interface Cards and Subscriber Line Units have been used interchangeably throughout the specification. Multiple configurations of SLUs shall be required to provide subscriber to primary multiplexer Bank interfacing for a variety of voice and data communications. In case there are changes in number or type of cards because of changes in
channel requirements, the contract price shall be adjusted accordingly.

The SLU interface requirements are discussed in the following subparagraphs:

(A) Voice Channels

The voice channel requirement is for (I) 4-Wire E&M trunking in support of PABX trunks & PLC VF and (II) 2-Wire telephonic interfaces. 2 wire SLUs shall be DTMF/TP optioned for 2-wire loop start or 2-wire GND start. The voice cards shall utilize ITU.T A-law companded PCM G.711, 64 kbits/s encoding. The voice card requirements are indicated in the BoQ in appendices.

(B) Sub-Channel Data Multiplexing

For this Project, the RTU data interface to the wideband telecommunications network node shall be defined at the DTE level at low-speed rates of 300, 600 and 1200 baud. The port shall be compatible with RS232C interface. The Contractor shall be required to furnish 64 Kbps SLU asynchronous dataplexing for at least 4 selectable low speed DTE interfaces whenever multiple asynchronous data circuits are required.

(C) Synchronous Data

The Contractor shall provide a direct DTE interface for synchronous communications at speed of 64Kbps and compatible with CCITT G.703 Kbit/s, V.35 and X.21 interfaces. Data rate selection shall be switch selectable or programmable.

(D) Nx64 kbps Synchronous Data

There is also a requirement for N x 64 kbps V.35, X.21 interfaces. The tentative quantities have been identified in the appendices. However the final BOQ shall be worked out during detailed design and contract price shall be adjusted accordingly.

2.5 MDF, DDF and Cabling

For the purposes of the specification, the contractor shall provide cabling, wiring, DDF patching facilities and MDFs interfacing to the wideband telecommunications system. Equipment and material components for MDF, DDF and cabling are also part of this procurement. It shall be the Contractor's responsibility to provide all cable support required for full supplied equipment interconnection with the MDF and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications.

2.5.1 Digital Distribution Frame Functional Requirements

The Contractor shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

(i) "Normally thru" circuit routing
(ii) Circuit rerouting via patch cord assemblies
(iii) Circuit disconnect and termination
All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

2.5.2 Main Distribution Frames

The Contractor shall make provision for cross connection of subscriber services to the subscribers utilizing Krone type or equivalent and shall provide full connectivity up to and terminated on the equipment side of the appropriate DDFs and line side of MDFs. The Contractor shall terminate on the equipment side of patching facilities provided by other contracts and shall provide DSX type patching facilities supporting aggregate bit streams (i.e. dataplexers and E-1 Channel Banks). Separate Patch panels or MDFs shall be provided for Data and Voice. All cross connects shall be accomplished utilizing one, two or three pair patch cords. Patch plugs are permissible for direct one-to-one circuit "cut-thru".

2.6 Patch Cords

The Contractor has to supply FC PC coupled Patch cords as described in BOQ. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

2.6 Telecommunication Management Network / Network Management System (As Applicable)

The Contractor shall provide a Telecommunications Management Network System (TMN) for operational support to the FOTS and associated Termination equipment subsystems. This TMN shall provide the capability to monitor, reconfigure, and control elements of the telecommunications network from a centralized location and at each node of the network where equipment is located. This TMN system shall assist Employer/Owner in the operations and maintenance of the wideband communication resources of the including detection of degraded circuits, system performance, the diagnosis of problems, the implementation of remedial actions and the allocation or reallocation of telecommunications resources and addition/deletion of network elements.

The contractor shall supply preferably a single TMN for all the NEs (Network Elements) such as SDH equipment, Mux, Drop-Insert, DACS etc. In case a single TMN can not be provided for all the NEs, the contractor may supply separate TMNs. Each of the offered TMNs shall meet the requirements indicated in this section. The bidder shall provide details of the offered TMN in the bid.

2.7.1 Applicable Standards

The TMN design concept, functional and informational architecture and physical architecture, shall be in compliance with ITU-T Recommendation M.3010. The offered TMN system shall be capable of integration to other supplier’s Network Management System (NMS) upwardly through North bound interfaces. The north bound interface in the EMS shall be CORBA/TMF-814 compliant.

2.7.2 TMN Architecture

The TMN shall provide
a. Collection of Management data from all Network Elements (NEs) supplied under this package. The minimum monitoring and control requirements for the communication equipment shall be as defined in this section.

b. Processing of above management data by using processor(s) located at control Centre and additional intermediate station processor(s), wherever required.

c. Monitoring and control of the NEs as defined below:

   I) TMN system at LDC (including local operator console, if applicable) shall support management of all equipments supplied and monitoring of the entire regional network supplied under this package. At a minimum functions of Network management layer (NML) and Element management layer (EML) as defined in CCITT M3010. The detailed functions are listed in TS.

   II) Monitoring and control of NEs using Craft Terminals as defined in this Section.

d. Supervisory monitoring and control of the following station associated devices:

   I) Intrusion Detection Alarms
   II) Power Failure
   III) Fire and Smoke Detection
   IV) Environmental Control (Temperature, Humidity etc.)

e. Communication channel support for TMN System as specified in Technical Specifications (TS).

The supplied TMN system shall be capable of handling all management functions for at least 150% of the final network elements. Further, the centralised TMN system shall also have provision for addition of at least two remote operator consoles. The TMN hardware shall be so designed that failure of a single processor/component (router, switch, converter etc.) shall not inhibit any of the functionality of the TMN at control centre. The Contractor shall submit for Employer’s approval the TMN architecture describing in detail the following subsystems/features:

a. Database used in TMN

b. Master Processor, server/workstation, LAN, Peripherals and hardware

c. Software and operating system

d. Local Consoles/remote consoles

e. Craft Terminals

f. Data communication between NEs, Remote/Local Consoles and TMN Processor(s)

g. Routers/Bridges

h. Expansion Capabilities

2.7.3 Management Functions

The TMN shall support following Management functions:

2.7.3.1 Configuration Management
Configuration management is concerned with management, display, and control of the network configuration. Minimum specific requirements that shall be satisfied include the following:

a. Provide tools to establish and maintain the backbone topology and configuration information and provide graphical maps depicting the configurations.

b. Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.

c. Provide tools for planning, establishing, and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades, and operator requests to take equipment offline for testing.

d. Provide verification testing to support new equipment installation.

2.7.3.2 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoration, and reporting on all the backbone network equipment, systems, and links. Minimum specific requirements that shall be satisfied include the following:

a. Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colours on links and nodes as well as through text.

b. Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity.

c. Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms. The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is encouraged to minimize the proliferation of alarms caused by a single, common event. All alarms shall be configurable as critical alarms, major alarms and minor alarms with different colours.

d. Provide the capability to diagnose and isolate failures through analysis of error and event reports and through the use of both on-line and off-line diagnostic tests and display of monitored data.

e. The criteria for fail over shall be configurable as automatic fail over to redundant equipment wherever possible and through operator-initiated actions where automatic fail over is not possible. The status of fail over shall be reported to the NMS.

f. Track network equipment failure history.
2.7.3.3 Performance Management

Performance management is concerned with evaluation of the use of network equipments and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

a. Provide support for an operator to initiate, collect, and terminate performance metrics under both normal and degraded conditions. For example, BER of each link, together with other data measured at each node, shall be available on operator request (atleast for SDH).

b. Monitor point to point & end to end signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources (atleast for SDH). Specifically provide displays to permit the operator to:

1. Select/deselect network equipments, events, and threshold parameters to monitor
2. Set monitoring start time and duration or end time
3. Set monitoring sampling frequency
4. Set/change threshold values on selected performance parameters
5. Generate alarm events when thresholds are exceeded.
6. Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.
7. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs. Performance data provided is limited to what is available from the equipment Contractors.
8. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.
9. Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

2.7.3.4 Security Management

The TMN shall be provided with security features to limit access to monitoring and control capabilities to only authorized personnel. One access level of System Administrator and at least two levels of operator access shall be provided - read (view) only, and write (configure). The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kind of maintenance and up gradation of the TMN system. With "read only" access level, network parameters should only be viewed. Access to database maintenance, command control and test functions shall be available with "write " access level. Means shall be provided to ensure only one authorized user has write capability for a selected domain of the network. It shall be possible to define multiple domains for purposes of monitoring and control.
Human error and conflict detection are also required. Such errors and access violations shall be reported to the offending user as error messages and warnings.

### 2.8 Communication Channel Requirement and Integration

Communication requirements for TMN system have not been considered in Appendices and the Contractor shall provide these as a part of TMN system. The Contractor shall provide all required interface cards / devices, LAN, routers/bridges, channel routing, cabling, wiring etc. and interfacing required for full TMN data transport.

The TMN data transport shall utilize the wideband communications transmission system service channel in the overhead whenever possible. This will provide inherent critical path protection.

Should the configuration requirements dictate multiple TMN station processors, the TMN Master Station shall require bidirectional data transport with its station processor(s). This communications interfacing shall be via critically protected data channels. It shall be the Contractor’s responsibility to provide for and equip all necessary critically protected TMN data channel support.

In case supervisory channels are not available, the Contractor shall provide suitable interfaces in their supplied equipment for transport of TMN data. The Contractor shall also be responsible for providing suitable channels with appropriate interfaces to transport the TMN data.

The NMS information of existing PDH & SDH system shall be transported through the new communication network, wherever required, up to the NMS location. The NMS information of the new SDH & PDH system being procured under the package shall be transported through the existing communication network using 64 kbps/2Mpbs (G.703) interfaces. Any hardware required for above interfacing shall be provided by the Contractor.

The bidders shall describe in the proposal the TMN data transport proposed to be used by the bidder in detail including capacity requirements and various components/equipment proposed to be used.

### 2.9 Craft Terminal

Each equipment (SDH equipment, Mux, Drop/Insert and DACS etc.) on the fibre optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. Through the use of this PC and local displays/controls, the operator shall be able to:

- a. Change the configuration of the station & the connected NEs.
- b. Perform tests
- c. Get detailed fault information

The craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with necessary system and application software to support the functions listed above, shall be supplied to the employer as per BOQ given in the appendices.

### 2.10 Hardware Requirements

#### 2.10.1 Master Processor, Server/Workstation and Craft Terminal

The server/workstation and craft terminal shall have suitable processor(s) which shall be sufficient to meet all the functional requirement and expansion capabilities stipulated in this
specification. Only reputed make like Dell, IBM, HP, Compaq make shall be supplied.

The server shall have minimum configuration of 3GHz for CISC based or 1.6GHz for RISC based processor, 2GB RAM, DVD-ROM drive, redundant 80 GB internal Hard Disk Drive, 101-Enhanced style keyboards, mouse, parallel, serial, USB(2.0) ports and hot swap redundant power supply. VDUs shall be 17" TFT active matrix color LCD with a minimum resolution of 1024 X 768. Appropriate network drive card shall also be provided wherever required. However, the internal hard disk drive for the server shall be redundant and all the data shall be mirrored. Further, the TMN software shall support data mirroring on redundant disk drives.

The workstation shall have minimum configuration of 2.4GHz for CISC or 1.4GHz for RISC based processor, 1GB RAM, DVD-RW drive, 160 GB Hard Disk Drive, 101-Enhanced style keyboards, mouse, parallel, serial and USB (2.0) ports. VDUs shall be 19" TFT active matrix color LCD with a minimum resolution of 1024 X 768. Appropriate network drive card shall also be provided wherever required.

CPU enclosures shall be desktop type and shall include available expansion slots except for the Craft Terminal which shall be a laptop. The craft terminal shall have minimum configuration of 2.4 GHz, 2 GB RAM, 256 MB VRAM, DVD RW drive, 160 GB Hard Disk Drive, keyboard, mouse/trackball etc., parallel, serial/USB (2.0) ports to accommodate printers, and Internal/external Data/Fax modem and a battery back-up of at least 60 minutes. VDUs shall be 15" TFT active matrix color LCD with a minimum resolution of 1024 X 768.

2.10.2 Peripherals and hardware

TMN system shall be provided with laser printer. The laser printer shall have a minimum print speed of 17 pages per minute and a minimum resolution of 1200 x 1200 dpi. The laser printer shall have parallel and LAN ports for connecting to TMN system.

The laser printer under this specification shall be black & white and include print enhanced buffering to prevent loss of print data in the event of a print failure.
2.10.3 Local/Remote Operator Consoles (As Applicable)

The Contractor shall provide operator consoles sized and equipped to support the subsystem(s) furnished and in compliance with the specification. The console shall provide hardware interfacing for the TMN users to the software operating support systems. At a minimum, a console shall include the hardware similar to a workstation.

2.10.4 Power Supplies

The TMN system shall use 220 volts 50 Hz A.C or -48 volt D.C as available at site for its operation as available at site.

2.11 General Software/Firmware Requirements

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.

2.11.1 Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, management devices, to allocate system resources, and manage communications among the system processors. The contractor shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

2.11.2 Applications Software

All applications software shall be written in a high-level programming language unless developed using industry proven application programs and development tools provided with the system. The contractor shall make no modifications to the applications program except as provided as USER development tools.

2.11.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

2.11.4 Revisions, Upgrades, Maintainability

All firmware and software delivered under this specification shall be the latest field proven version available at the time of contract approval. Installed demonstration for acceptance shall be required. All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

All software shall be easily user expandable to accommodate the anticipated system growth, as defined in this specification. Reassembly recompilation or revision upgrades of the software or components of the software, shall not be necessary to accommodate full system expansion.

Software provided shall be compliant with national and international industry standards.

2.11.5 Database(s)
The contractor shall develop all the databases for final wideband network following the global acronyms for all stations. Database(s) to be provided shall contain all structure definitions and data for the integrated functional requirements of TMN system.

TMN operator Groups shall share the same virtual database. This means that they shall share the same database and database manager, whether or not physically separate databases are maintained.

2.11.6 Help

All applications shall be supported by USER accessible HELP commands that shall assist the user in the performance of its tasks. HELP commands for an application shall be available to the user from within the active application and shall not interfere with the activities of the application.
FIBRE OPTIC BASED COMMUNICATION EQUIPMENTS

SECTION – 3

ENVIRONMENT, EMI, POWER SUPPLY, CABLELING AND EARTHING

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3.1.3 Vibration and Shock Resistance

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FIBRE OPTIC BASED COMMUNICATION EQUIPMENTS

SECTION – 3

ENVIRONMENT, EMI, POWER SUPPLY, CABLING AND EARTHING

The purpose of this section is to describe the minimum general equipment characteristics and specifications for environmental conditions, source power conditioning and backup, equipment construction, and installation. The section also highlights the stringent Electro Magnetic Compatibility (EMC) guidelines for equipment that will be operated under the severest Electro Magnetic Interference (EMI) and Electro Static Discharge (ESD) conditions expected in an Extra High Voltage (EHV) power system environment.

3.1 Environmental Requirements

Equipment and their components provided under this specification shall operate reliably under the following environmental conditions.

3.1.1 Temperature and Humidity

Most of the equipment will not be installed in environmentally controlled shelters. Therefore, equipment shall operate in accordance with the limits shown in Table 4-1.

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</tr>
<tr>
<td></td>
<td>-40 to 60°C</td>
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<tr>
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</tr>
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<td>Non-operating</td>
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</table>

For each location, the Contractor is required to assess the environmental conditions for the equipment to be installed under this specification. The Contractor is responsible for all necessary enclosure, rack or equipment upgrades to ensure the proper operation of the installed equipment.

3.1.2 EMI and Electrostatic Interference

At each location, the Contractor shall assess the need for shielding against radiated emissions and shall provide recommended solutions for any EMI problem found at each location. Specifications provides the type of immunity tests for which the equipment shall be required to pass without failure. For the individual tests to be carried out at the different interfaces, references are made to the relevant IEC and ITU-T recommendations.

3.1.3 Vibration and Shock Resistance

As per testing requirements indicated in this specification.
3.1.4 Tropicalization

Communications equipment will often be stored and operated in uncontrolled environment areas and will be subject to mould, growth of fungus, corrosion and oxidation. The equipment and components shall be suitably tropicalized during manufacture through commissioning, as necessary.

3.1.5 Contaminants

Communications equipment may be located in areas of poor air quality with the main contaminant being dust. Cabinets shall be tight fitting utilizing filtered ventilation openings only.

3.2 Primary Source AC/DC Power Requirements

Facilities will be required to support both AC and DC power load requirements of telecommunications equipment as specified below:

3.2.1 Primary Source AC Power

It will be the Employer's responsibility to provide required Primary AC source Power for communications equipment installed under this specification. The Primary AC Power supplied will be 240 VAC ± 10%, 50Hz with a frequency variance between 46 and 55 Hz. Harmonic distortion will not exceed five (5) percent.

All equipment and components provided under this specification requiring Primary AC Power, shall be designed for normal operation under the above stated tolerances for 240 VAC supply.

The Contractor shall provide in their Bid as well as in the survey report to the Employer the projected 240 VAC Primary Power load requirement per equipment and totals, by location, for equipment provided under this specification. The Contractor shall provide suitable UPS for communication equipment/module etc. requiring AC power supply at locations other than control centre.

3.2.2 -48V DC Power

Power supplies/converters for communications equipment (except computer system supplied as part of NMS which shall use 240 VAC) provided under this specification, shall use -48Vdc uninterrupted primary source power. The power supply may vary normally within the voltage range -42 to -58 Vdc and the supplied equipment shall operate satisfactorily within this range.

3.2.3 Power Distribution and Protection

The Employer will furnish only one source primary 240 VAC and/or -48 VDC power. It shall be the Contractor's responsibility for the connection and distribution of all Primary AC and -48V dc source power, in full compliance with all local and national electrical codes.

The Employer shall indicate during the survey by Contractor, on the primary source, the feeders/points that can be used by the Contractor. The Contractor shall supply & install Primary AC and -48Vdc feeder cables to Contractor-furnished distribution panels.

The Contractor shall provide required distribution panels, circuit breakers and appropriate Panel Disconnects. Distribution Panel feeders, Panel Disconnects, distribution panels and circuit breakers shall be sized and equipped to support at least 100% expanded load requirements.

The Contractor shall provide and install all required primary power distribution sourced from the distribution panels. The Contractor shall also be responsible for Load Balancing.
The Contractor is responsible for all inter-rack (enclosure) and intra-rack (enclosure) power distribution required to support equipment supplied under this specification. The Contractor shall provide all cabling, fusing, switching and circuit breaker and surge protection required.

Partially equipped subsystems shall be installed with provision for expansion. Equipment power supplies provided under this specification, shall be sized to support fully equipped subsystems. Primary power distribution protection shall be sized to support and protect maximum operating load potential whether or not the actual projected load shall meet that maximum load potential.

The Contractor shall provide equipment and rack safety earthing in compliance with this specification.

3.3 Equipment Construction, Assembly and Installation

All equipment supplied under this specification shall be constructed, assembled and installed in accordance with the following requirements:

3.3.1 Identification

All cabling, racks/enclosures, equipment, modules and materials shall be uniquely identifiable as per the following:

3.3.1.1 Equipment

Each equipment component to the level of printed circuit card, shall be clearly marked with the manufacturer’s part number, serial number, month/year of manufacture and revision level. Changes to components shall be identified by an unambiguous change to the marked revision level. The Contractor shall be responsible for maintaining the master revision level list until the Contractor has complied with all requirements of this specification.

Where custom components and parts are provided, each component/part shall be marked to specifically identify that component/part. Printed circuit card cages are defined as an equipment component and as such, shall be clearly identified as stated within this specification.

Equipment chassis and printed circuit card cages having wired backplanes, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture, revision level and an additional identifier corresponding directly to the applicable backplane wiring diagram/list.

3.3.1.2 Power Distribution

Power distribution panels shall be clearly marked with their unique identifier, source feed information, and remote source feed emergency disconnect location and identity.

Power distribution panel "Main Disconnect" and circuit breakers shall be clearly marked with a unique identifier. Circuit breaker feed lists shall be clear, accurate and the feed list information shall be posted inside each distribution panel door.

Inter-rack and intra-rack (enclosure) power distribution shall be clearly identified with source feed, voltage and power rating information. All power feed cabling shall be clearly identified near the point of termination.

All power distribution identification shall utilize heat-resistant permanent marking techniques such as stamped non-metallic tags, embossed labels, etc. Marking techniques are subject to approval by the Employer. Power distribution identifiers and information shall agree with the
Contractor's power cable plant drawings.

3.3.1.3 Signal Cabling

Connecterised signal cabling/wiring requires marking with a unique identifier at each connecterised end. The signal cable/wire identifier shall include a cable identifier and the location of both terminations.

Signal cable/wiring installed on terminal blocks requires marking with the cable identifier and distant end location. The cable tag shall be clearly visible at the cable fan-out point.

All signal cable, wiring and terminations shall be clearly labeled/tagged with identifiers consistent with Contractor supplied cable plant records. Marking techniques are subject to approval by the Employer.

3.3.1.4 Equipment Racks and Enclosures

All equipment racks, enclosures and equipment, including distribution frames, shall be clearly labeled with unique identifiers consistent with Contractor supplied floor plans and rack elevations.

3.3.2 Installation Hardware

Equipment racks, enclosures, cable raceways and installation hardware shall, at a minimum, comply with the following requirements:

3.3.2.1 Equipment Sub-Racks and Cabinets (Enclosures)

All equipment provided under this specification, shall be physically mounted in sub-racks and cabinets (enclosures). The Contractor shall determine and propose for the Employer approval, the type, size, weight and manner of installation for each location.

Selection of equipment sub-racks and cabinets (enclosures) shall meet the following requirements:

(A) Equipment SubRack Construction

Equipment Sub Racks provided for installation in environmentally controlled facilities, shall meet the following minimum requirements:

(1) Equipment Sub Racks shall be steel/aluminum fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.

(2) Equipment covers shall be provided for exposed components mounted in equipment sub Racks.

(3) Dust and moisture protection shall meet or exceed IP20 standards.

(B) Equipment Cabinet (Enclosure) Construction

(1) Equipment cabinets (enclosures) shall be steel/ steel & Aluminium extrusion fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for
rust and primed to form a bond between metal and the finish coats of paint.

(2) Equipment cabinets (enclosures) shall be designed free-standing but shall be mounted to the floor. Cabinets (enclosures) shall have secure fitting, lockable, full-length front doors for access to hardware and wiring. Equipment covers for exposed components mounted inside cabinets are not required unless specifically recommended.

(3) All doors and removable panels shall be fitted with long life rubber beading. All panels shall be fabricated from minimum 2.0mm thickness steel sheet. However, for racks with load bearing Aluminium extrusion frame, door panels and side panels may be fabricated from minimum 1.6mm thickness steel sheet and the top & bottom panels shall be fabricated from minimum 2.0mm thickness steel sheet.

(4) Equipment cabinets (enclosures) shall be dust and moisture-proof as per IP41 specification, or better.

3.3.2.2 Cable Raceways

The Contractor is required to provide and install all additional necessary indoor and outdoor cable raceways. The cable raceways shall be in conformance with the following:

(1) Signal cabling and power cabling shall require separate cable raceways. Signal and power cabling shall not share the same raceways and shall be installed as far apart as is practical. Adequate shielding shall be provided as required.

(2) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

(3) Outdoor cable raceways shall be of corrugated construction and shall be fitted with solid covers overlapping all sides of the cable raceways.

(4) Outdoor cable raceways shall be fabricated from construction grade aluminum, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be taken. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.

(5) Indoor cable raceways fabricated of aluminum or galvanized iron, shall not normally need special finishing or painting, unless otherwise stipulated by the Employer. Steel fabricated raceways shall require a red oxide primer coat at a minimum.

3.3.3 Signaling Distribution

The Contractor shall be responsible for all signal wiring associated with furnished equipment in accordance with the following:

(1) All signal wiring connections to the communications equipment shall be via Krone type or equivalent terminal blocks.

(2) The Contractor shall provide subscriber level wiring and patching wherever required.

3.3.4 Lightning and Transient Voltage Protection
The Contractor shall be required to provide protection from lightning and transient voltages for all wideband communications equipment, in accordance with the following:

1. At the outside cable plant point-of-entry of all cabling penetrations for all cabling installed by the Contractor, the Contractor shall provide lightning and transient voltage isolation for the inside plants cabling, wiring, and all terminations and equipment.

2. All equipment installed under this specification that requires 240VAC primary power, shall be surge protected.

3.3.5 Station Safety Earthing and Signal Grounding

For each facility, the Contractor is responsible for meeting the following station and equipment earthing requirements:

1. All safety earthing and signal grounding shall be in full compliance with EMI/EMC requirements as per relevant international standards.

2. Each cabinet (enclosure) or cabinet (enclosure) group shall include suitable signal ground and safety earth networks. The signal ground network shall terminate at a separate signal ground stud connection isolated from safety earth.

3. Each earth/ground network shall utilize copper bus bars, copper braids and/or 16 sqmm or bigger earth cable. All equipment earth/ground connections shall be made directly to the equipment chassis utilizing grounding lugs and secured metal-to-metal with star washers. Use of the enclosure frame, skin or chassis mounting hardware as part of the earthing/grounding networks, is not acceptable.

4. The safety earth network shall be connected to "earth ground" at the safety earth stud. The earth stud connection shall be sized for an external earthing cable equipped with a 2/0 solid copper lug secured metal-to-metal with star washers. Primary AC feeds and distribution within enclosures requires earthing wire connection to the safety earth stud.

5. The safety earth and signal ground networks shall be inter-connected only at the safety earth stud and signal ground stud.

The Contractor shall extend the existing station earth to the equipment room using suitable G.I. earthing strip (50 x 6 mm), wherever required.

The Contractor is responsible for providing all required earthing/grounding cable and installation. Cabinet (Enclosure) and equipment safety earthing and signal grounding shall be subject to the Employer’s approval.

The Contractor shall be responsible for determining the suitability of existing station earth for the equipment to be supplied under this contract. In case existing earthing arrangement at the site is not adequate, the Contractor shall either make improvement in the existing earthing arrangement or make new earthing as per requirement.

3.3.6 Interconnections

All power and signal cabling between component units of the communications systems shall be supplied and installed by the Contractor and shall be shown on contractor-supplied as-built drawings.
The Contractor shall supply and install all primary power cords, powerstrips, receptacles, circuit breakers, fuse panels, switches, earth fault detectors, surge protectors, distribution cabling, and power connectors required to support all equipment enclosures and system components furnished and installed under this specification, except as specifically excluded.

Plug-type power connectors with captive fastening (such as "Twist-Lock") shall be used for interconnection of source power to the equipment enclosures or racks.

Plug-type connectors with captive fasteners (ie. DB-25, etc) shall be used for the interconnection of all inter and intra-enclosure signalling cable.

3.3.7 Finish Colors

Unless otherwise specified, finish colors for enclosures shall be gloss white enamel on the inside, and semi-gloss medium grey enamel on the outside. Only brushed aluminum trim shall be used. Employer reserves the right to approve the proposed color scheme.

3.4 Location of Equipment, Cable Routes and Associated Civil Works

During the Site Surveys, the Contractor shall determine and propose locations for all equipment to be supplied under this contract. Further, the Contractor shall locate and identify proposed routing for all cabling between all equipment locations including existing and planned equipment not provided under this contract, but required to be connected under the scope of this contract. This subsection defines the requirements and clarifies the responsibilities of the Employer and the Contractor regarding equipment siting, intra and inter facility interconnectivity and necessary associated civil works.

3.4.1 Locations for Supplied Equipment

All transmission equipment and associated DDFs and MDFs, shall generally be colocated in the same communications room located in the Control Building whenever possible.

3.4.2 Associated Civil Works

The Contractor shall provide all required minor civil works necessary for full connectivity as required in the Contractor’s scope of work as follows:

(1) All wall and floor penetrations necessary for the installation of all cabling to be performed in accordance with the requirements of this specification.

(2) Installation of racks, cabinets, cable raceways, and cabling supplied as part of this contract.

3.4.3 Cable Trenches

A network of cable trenches and/or ducts may exist at some sites but shall require expansion and/or new construction at some stations. It shall be a responsibility of the contractor to cooperate fully with the Employer and all other on-going project contractors in the planning and efficient use of existing and new cable trenches. The existing cable trenches/cable raceways proposed to be used shall be identified in the survey report. The contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be proposed for Employer approval. The Employer shall provide any additional cable trenches required for such approved alternatives.
It may be noted that in order to utilise the existing trenches, the Contractor supplied cables may be required to be co-located with LV cables. Accordingly, the contractor shall ensure that selection and installation of cables is suitable for the purpose. The contractor shall be responsible for new building penetrations required for supplied cabling. Caution shall be taken to ensure existing equipment and site personnel are protected from dust and debris incident to the cable penetration work. Penetration shall be neatly formed and sealed for protection from moisture, dust wind and vermin intrusion.

All required fitting, supports, accessories, ducts, inner ducts, conduits, riser and any item not specially mentioned but required for lay and installation of cables in trenches shall be supplied and installed by the Contractor.

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# FIBRE OPTIC BASED COMMUNICATION EQUIPMENTS

## SECTION - 04

### INSPECTION, TEST AND AVAILABILITY

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FIBRE OPTIC BASED COMMUNICATION EQUIPMENTS

SECTION - 04

INSPECTION, TEST AND AVAILABILITY

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer’s representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

All security related features shall be demonstrated during FAT/SAT as required by the Employer.

4.1 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

(a) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in
accordance with the Specification shall be provided by the Contractor to the Employer.

(b) Inspections to be performed by the Employer will include visual examination of hardware, cable dressings and labeling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.

(c) Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.

(d) The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.

(e) The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

4.2 Test Plans and Procedures

Test plans and test procedures for both factory and site acceptance tests shall be provided by the Contractor. Test plans and test procedures shall ensure that each factory and site test is comprehensive and verify all the features of the equipment to be tested. Test plans and test procedures shall be modular to allow individual test segments to be repeated upon request.

The Contractor shall submit a Test Schedule for the Employer's approval within one (1) week after the award of contract for Type Tests and three (3) months after the award of contract for all other tests. The test schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the work.

The Contractor shall give the Employer twenty one (21) days written notice of any material being ready for testing. Fifteen days prior to the scheduled testing, the Employer shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer's opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid, effecting the corrections as necessary or shall prove, in writing, that said modifications are unnecessary for contract compliance.

4.2.1 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table 4-1.
Table 4-1
Factory & field Test Plan Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Test schedule</td>
</tr>
<tr>
<td>2.</td>
<td>Record-keeping assignments, procedures and forms</td>
</tr>
<tr>
<td>3.</td>
<td>Procedures for monitoring, correcting and retesting variances</td>
</tr>
<tr>
<td>4.</td>
<td>Procedures for controlling and documenting all changes made to the communications equipment after the start of testing</td>
</tr>
</tbody>
</table>

4.2.2 Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval at least four (4) weeks before each individual test. Fully approved test procedures shall be submitted to the Employer at least four weeks prior to the commencement of testing. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table 4-2.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/jig manufacturer recommended calibration interval or the interval recommended in the test lab’s internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

Table 4-2
Test Procedure Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Test Title and Revision Level, if applicable</td>
</tr>
<tr>
<td>2.</td>
<td>List of Standard(s) complied with</td>
</tr>
<tr>
<td>3.</td>
<td>Function(s) / parameter(s) to be tested</td>
</tr>
<tr>
<td>4.</td>
<td>Purpose of each test segment</td>
</tr>
<tr>
<td>5.</td>
<td>List of required test equipment</td>
</tr>
<tr>
<td>6.</td>
<td>Description of any special test conditions or special actions required. This includes complete descriptions, listings and user interface procedures for all special hardware and software tools and/or display formats to be used during the test.</td>
</tr>
<tr>
<td>7.</td>
<td>Test setup including test configuration block diagrams and/or illustrations.</td>
</tr>
<tr>
<td>8.</td>
<td>Test procedures to be followed.</td>
</tr>
<tr>
<td>9.</td>
<td>Required inputs and expected outputs for each test segment</td>
</tr>
<tr>
<td>10.</td>
<td>Acceptance criteria for each test segment.</td>
</tr>
</tbody>
</table>
### Table 4-2
**Test Procedure Requirements**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>List of test data to be supplied by the Contractor(s) and copies of any certified data to be used</td>
</tr>
<tr>
<td>12.</td>
<td>Format of test reports.</td>
</tr>
</tbody>
</table>

### 4.2.3 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table 4-3.

### Table 4-3
**Test Record Requirements**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Test Title and Revision Level, if applicable; contract references</td>
</tr>
<tr>
<td>2.</td>
<td>Date and time for test start and test completed</td>
</tr>
<tr>
<td>3.</td>
<td>Test title and reference to the appropriate section of the test procedures</td>
</tr>
<tr>
<td>4.</td>
<td>Description of any special test conditions or special actions taken (Includes test-case data).</td>
</tr>
<tr>
<td>5.</td>
<td>Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.</td>
</tr>
<tr>
<td>6.</td>
<td>Test procedure modifications made during testing.</td>
</tr>
<tr>
<td>7.</td>
<td>Variance Report(s) tracking information and copies (if variance(s) was detected).</td>
</tr>
<tr>
<td>8.</td>
<td>Contractor's test engineer(s) identification, signature and remarks</td>
</tr>
<tr>
<td>9.</td>
<td>Employer's test witness identification, signature and remarks</td>
</tr>
<tr>
<td>10.</td>
<td>List of all attachments</td>
</tr>
<tr>
<td>11.</td>
<td>Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)</td>
</tr>
</tbody>
</table>

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test. These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within the specified duration after the completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading.

### 4.2.4 Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary.

Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer.
for further inspection and/or tests.

4.2.5 Test Periods Defined

The terminology used in Volume I, General Conditions of Contract and their correlation with the tests requirements described within this section is as follows:

Pre-Commissioning & Commissioning Period - The Site Acceptance Test (SAT)
Operational Acceptance - Successful completion of SAT

4.3 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

(a) All equipment being supplied shall conform to type tests as per technical specification.

(b) The test reports submitted shall be of the tests conducted within last five (5) years prior to the date of bid opening. In case the test reports are older than five years (5) ago on the date of bid opening, the Contractor shall repeat these tests at no extra cost to the purchaser.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer's representatives.

In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
(h) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

4.3.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. At least three samples of each of the proposed equipment shall be offered for selection, out of which one sample for each equipment shall be selected.

4.3.2 List of Type Tests

The type testing shall be conducted on the following equipment

(a) SDH Equipment with all types of cards (optical card, Tributary card or any other equipment as part of repeater less links)
(b) Primary Multiplexer & Drop – Insert Multiplexer with subscriber interface card

4.3.2.1 List of type test to be conducted on Telecom equipment

The type tests for SDH Equipment with all types of cards, Primary Multiplexer & Drop – Insert Mux with subscriber interface card are described below:

4.3.2.1.1 Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 60068.

(a) Low Temperature Test: Operation to Specifications

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.

(2) Degree of Severity: Test shall be done at 0°C

(3) Acceptance Criteria: No degradation of performance during and after the test.

(b) Low Temperature Test : Operation without Damage
Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

1. **Test Duration**: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

2. **Degree of Severity**: Test shall be done at -10°C.

3. **Acceptance Criteria**: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the *post-test*.

---

### (c) Dry Heat Test: Operation to Specifications

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

1. **Test Duration**: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test.

2. **Degree of Severity**: As per table 5-1: operation to specification range.

3. **Acceptance Criteria**: No degradation of performance during and after the test.

---

### (d) Dry Heat Test: Operation without Damage

Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

1. **Test Duration**: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

2. **Degree of Severity**: Test shall be done at 55°C.

3. **Acceptance Criteria**: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the *post-test*.

---

### (e) Damp Heat Test

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-3 with the following specifications:

1. **Test Duration**: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.
(2) **Acceptance Criteria:** The equipment shall meet the specified requirement and there shall not be any degradation in BER.

(f) **Temperature Variation Test**

Temperature variation testing shall be as per IEC Publication 60068-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

1. Number of cycles required is five (5)
2. The degree of severity: temperature TL:0°C, TH: As per table 5-1 (Operation to specification range)
3. Cycle duration for each temperature is three (3) hours.
4. Ramp: 1 °C/minute.
5. **Acceptance Criteria:** The equipment shall meet the specified requirement and there shall not be any degradation in BER.

4.3.2.1.2 **Power Supply and EMI/EMC tests**

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.

(a) **Immunity Tests**

The list of Immunity tests are specified below in Table 4-4:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Immunity Test</th>
<th>AC Power Supply</th>
<th>DC Power Supply</th>
<th>Control &amp; Signal</th>
<th>Telecom Line</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Voltage Fluctuations</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
<td>Table 11 of IEC 60870-2-1: 1995 - Level 1</td>
</tr>
<tr>
<td>2</td>
<td>Voltage dips and Interruptions</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.2/50 - 8/20 μs surges</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Fast transient bursts</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Table 12 of IEC 60870-2-1: 1995 - Level 4</td>
</tr>
<tr>
<td>5</td>
<td>Damped oscillatory waves</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>10/700 μs surges</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Electrostatic discharge</td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
<td>Table 13 of IEC 60870-2-1: 1995</td>
</tr>
</tbody>
</table>
Table 4-4: Recommended Immunity Tests

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Immunity Test</th>
<th>AC Power Supply</th>
<th>DC Power Supply</th>
<th>Control &amp; Signal</th>
<th>Telecom Line</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Power frequency magnetic field</td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
<td>Table 14 of IEC 60870-2-1: 1995 - Level : 4</td>
</tr>
<tr>
<td>9</td>
<td>Damped oscillatory magnetic field</td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
<td>Table 15 of IEC 60870-2-1: 1995 - Level : 4</td>
</tr>
<tr>
<td>10</td>
<td>Radiated electromagnetic field</td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
<td>IEC 61000-4-16 : 2002-07 Level : 4</td>
</tr>
<tr>
<td>11</td>
<td>Power Frequency voltage on control and signal lines</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>Yes</td>
<td>IEC 61000-4-16 : 2002-07 Level : 4</td>
</tr>
<tr>
<td>12</td>
<td>DC voltage on control and signal lines</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>N/A</td>
<td>IEC 61000-4-16 : 2002-07 Level : 4</td>
</tr>
</tbody>
</table>

-End of Table-

(b) Emission Tests

The list of Emission tests are specified below in Table 4-5
Table 4-5:
Recommended Emission Tests

<table>
<thead>
<tr>
<th>S. NO.</th>
<th>Emission test</th>
<th>AC Power Supply</th>
<th>DC Power Supply</th>
<th>Control &amp; Signal</th>
<th>Telecom Line</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LF disturbance voltages</td>
<td>N/A</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
<td>Table 17 of IEC 60870-2-1: 1995 - Class : B</td>
</tr>
<tr>
<td></td>
<td>CCITT recommendation P.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>RF disturbance voltages</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CISPR 22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>RF disturbance currents</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CISPR 22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RF radiated fields</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CISPR 22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

-End Of Table-

(c) Insulation Withstand Voltages

As per section 6 of IEC 870-2-1. Recommended class : VW1 of Table 18.

4.3.2.1.3 Mechanical Tests

(a) Mechanical Vibration Test

The procedure for this test is described in IEC Publication 60068-2-6. The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6.

For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.

The endurance test conditions are selected according to the vibration withstand requirements.

Transportation tests shall be performed with the equipment packed according to the Contractor’s specifications.
(b) Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semi-sinusoidal shape (clause 3.1.1.2).

The recommended severity shall be $A = 294 \text{ m/s}^2$, $D = 18 \text{ ms}$. Three shocks per axis per direction shall be applied to the equipment packed according to the Contractor's specifications.

Or Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68-2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

Or Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 60068-2-29.

4.4 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on SDH Equipments, associated line & tributary cards, Termination Equipments (Primary Mux, Drop/Insert, associated Subscriber Line Interface Cards etc) and all other items for which price has been identified separately in the Bid Price Schedules.

Equipment shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer’s representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system and NMS are given in specified Tables in this section. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the other items shall be proposed by the Contractor in accordance with technical specifications and Contractor’s (including Sub-Contractor’s / supplier’s) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.
For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer’s final inspection certificate/report.

### 4.4.1 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected. In case a number of equipments are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipments which are necessary to demonstrate the performance, irrespective of the percentage.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/approvals until such a report is made and remedial actions taken, as applicable.

### 4.4.2 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor’s standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along with information such as sampling frequency, applicable standards, acceptance criteria etc.

#### Table 4-6:

**Factory Acceptance Testing for Fibre Optic Transmission System**

<table>
<thead>
<tr>
<th>Item:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Physical inspection for conformance to DRS, BOQ, drawings and appearance of equipment</td>
</tr>
<tr>
<td>2.</td>
<td>Optical output power</td>
</tr>
<tr>
<td>3.</td>
<td>Transmitter lightwave spectral analysis</td>
</tr>
<tr>
<td>4.</td>
<td>Low receive level threshold</td>
</tr>
<tr>
<td>5.</td>
<td>Generation of bit error rate curve</td>
</tr>
<tr>
<td>6.</td>
<td>Measurement of analog and digital service channel parameters as well as service channel functionality</td>
</tr>
<tr>
<td>7.</td>
<td>Performance of supervision, alarm, Craftsperson interface, diagnostics, loop backs etc.</td>
</tr>
</tbody>
</table>
Table 4-6: Factory Acceptance Testing for Fibre Optic Transmission System

<table>
<thead>
<tr>
<th>Item</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for multiplexers</td>
</tr>
<tr>
<td>9.</td>
<td>At a minimum tests on Ethernet interface shall include demonstration of ping test, throughput test, Latency test, Packet Loss test as per RFC 2544</td>
</tr>
<tr>
<td>11.</td>
<td>Simulation of failure conditions and failover of each redundant unit.</td>
</tr>
<tr>
<td>12.</td>
<td>Test of spare card slots</td>
</tr>
<tr>
<td>13.</td>
<td>Checks of power supply/converter voltage margins</td>
</tr>
<tr>
<td>14.</td>
<td>Random inspections to verify the accuracy of documentation</td>
</tr>
<tr>
<td>15.</td>
<td>Test of spare parts/modules/cards as per applicable tests</td>
</tr>
</tbody>
</table>

Table 4-7 Factory Acceptance Testing Requirements for Termination Equipment (MUX)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Physical Inspection for conformance to DRS, BOQ, drawings and appearance of equipment</td>
</tr>
<tr>
<td>2.</td>
<td>Performance of supervision, alarm, control and switching systems, diagnostics, loopbacks, Craftsperson interface etc.</td>
</tr>
<tr>
<td>3.</td>
<td>Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for the channel banks/low-level multiplexers</td>
</tr>
<tr>
<td>4.</td>
<td>Framing, signaling, and operational and maintenance tests consistent with applicable ITU-T requirements</td>
</tr>
<tr>
<td>5.</td>
<td>Simulation of failure conditions and failover of each redundant unit</td>
</tr>
<tr>
<td>6.</td>
<td>Test of spare card slots and test of spare parts/modules/cards as per applicable tests</td>
</tr>
<tr>
<td>7.</td>
<td>Checks of power supply/converter voltage margins and short circuit and overvoltage protection</td>
</tr>
<tr>
<td>8.</td>
<td>Random inspections to verify the accuracy of documentation</td>
</tr>
</tbody>
</table>

Table 4-8 FAT on Craft Terminal

<table>
<thead>
<tr>
<th>Item</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Physical inspection of Craft Terminal hardware for conformance to approved BoQ, DRS &amp; drawing</td>
</tr>
<tr>
<td>2</td>
<td>Testing of Craft Terminal to demonstrate proper operation of all functions</td>
</tr>
</tbody>
</table>
4.5 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for Telecom equipment, is outlined in following section. This testing shall be supplemented by the Contractor’s standard installation testing program, which shall be in accordance with his quality plan(s) for Telecom equipment installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

4.5.1 Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

4.5.1.1 Installation Testing

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense.

In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated.

The minimal installation testing requirements for fiber optic transmission subsystem, Termination equipment sub-system are provided in respective Tables in this section.

4.5.1.2 Link Commissioning Tests

The commissioning tests shall verify that communication can be performed over the fiber optic link under test. Delay measurement, Bit Error measurements & service channel performance monitoring shall be made on the fibre optic links to verify compliance with designed link performance.

For Ethernet interface: At a minimum the following test requirements shall be demonstrated as per RFC 2544:
  a) Ping test
  b) Throughput test
  c) Latency test
  d) Packet Loss

10% of the total links (Chosen by the Employer, generally to cover links from all configurations
used) shall be tested for a duration of 12 Hours. Rest of the links shall be tested for 1 Hour. In case a link does not meet the performance requirements during 1 hour, then the duration of the test shall be increased to 12 hours.

In case any link does not meet the performance requirements during 12 hour, then the cause of failure shall be investigated and the test shall be repeated after rectifying the defects.

This phase of testing shall be conducted by the Contractor and witnessed by the Employer. Field adjustments shall be made to meet established standard, however if the field adjustments fail to correct the defects the equipments may be returned to the Contractor for replacement at his own expense. In case any adjustments are required to be made during the interval of the test then the test shall be repeated.

4.5.1.3 Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the data and voice channel required to interconnect the various User’s interfaces. The integrated testing for a batch shall include end-to-end testing of back-bone network included in that batch. Integrated testing for last batch shall include testing of the entire back-bone. The intent of integrated testing is to demonstrate that the equipment is operational end to end under actual conditions, that all variances identified during factory and field installation and communications testing have been corrected, and that the communication equipment is compatible with other equipment at all locations. The Integrated System Test shall include all fibre optic transmission equipment, termination equipment, the network management subsystem and other components.

At a minimum the following tests shall be included in the integrated testing:

(1) Equipment configuration shall be checked to establish that it supports the channel routing.
(2) End to end testing of all individual voice circuits
(3) End-to-end testing of all individual Data Circuits.
(4) Demonstration of Protection switching and synchronization of equipment as per synchronization plan.

Table 4-9
Fibre Optic Transmission system Installation Testing

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling</td>
</tr>
<tr>
<td>2.</td>
<td>Station power supply input and equipment power supply (DC-DC converter) output voltage measurements</td>
</tr>
<tr>
<td>3.</td>
<td>Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.)</td>
</tr>
<tr>
<td>4.</td>
<td>Service channel performance</td>
</tr>
<tr>
<td>5.</td>
<td>Craftsperson interface, alarm and control functional performance</td>
</tr>
<tr>
<td>6.</td>
<td>Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional</td>
</tr>
<tr>
<td>7.</td>
<td>Network management interface and supervision performance</td>
</tr>
</tbody>
</table>
| 8.   | Correct configuration, level setting & adjustments and termination of Input/
output interfaces

9. Proper establishment of Safety and signalling earthing system and resistance to ground to be checked.

10. Simulation of failure conditions and failover of protected components.

### Table 4-10
Termination Equipment Sub-system Installation Testing

<table>
<thead>
<tr>
<th>Item:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling</td>
</tr>
<tr>
<td>2.</td>
<td>Power supply/converter voltage measurements</td>
</tr>
<tr>
<td>3.</td>
<td>Muldem performance testing</td>
</tr>
<tr>
<td>4.</td>
<td>Craftsperson interface, alarm and control functional performance</td>
</tr>
<tr>
<td>5.</td>
<td>Rack and Local alarms</td>
</tr>
<tr>
<td>6.</td>
<td>Network management interface and supervision performance</td>
</tr>
<tr>
<td>7.</td>
<td>Channel performance</td>
</tr>
<tr>
<td>8.</td>
<td>Safety and signalling earthing system</td>
</tr>
<tr>
<td>9.</td>
<td>Simulation of failure conditions and failover of protected components.</td>
</tr>
</tbody>
</table>

### Table 4-11
NMS Installation Testing (if Applicable)

<table>
<thead>
<tr>
<th>Item:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Physical inspection for conformance to drawings, rack elevations and appearance of equipment and cabling</td>
</tr>
<tr>
<td>2.</td>
<td>Workstation hardware inventory, configuration and characteristics</td>
</tr>
<tr>
<td>3.</td>
<td>Demonstration of proper operation of all hardware, including workstations peripherals</td>
</tr>
</tbody>
</table>
FIBRE OPTIC BASED COMMUNICATION EQUIPMENTS

SECTION 5

TRAINING AND SUPPORT SERVICES

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5.1 Training 

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This section describes the requirements for Contractor-supplied training, support services, and maintenance of the FOTS, Terminations equipments sub-systems, etc. The intent of the training and support program is to ensure a smooth transfer of systems and technologies from the Contractor to the Employer, and to ensure that Employer staff is fully trained to operate, maintain and expand the integrated telecommunication network.

5.1 Training

The Contractor shall provide a comprehensive training program that prepares the Employer’s personnel for on-site installation support, operation, and maintenance of the telecommunication network.

Training may be conducted by the Contractor, the Contractor’s subcontractors, and/or original equipment manufacturers (OEMs). The training requirements of this Specification shall apply to all such courses.

Training courses shall be conducted by personnel who speak understandable English and who are experienced in instruction. All necessary training material shall be provided by the Contractor. The training charges quoted by the Contractor shall include training materials and all associated expenses. However, for all training courses in India or abroad, the travel (e.g., airfare) and per diem expenses of the participants will be borne by the Employer. For courses conducted abroad, however, the Contractor shall extend all necessary assistance for making appropriate lodging arrangement.

Hands-on training shall be provided with equipment identical to that being supplied to the Employer.

The schedule, location and detailed training contents shall be submitted by the Contractor to the Employer for approval.

5.1.1 System Design & Overview Training

This training shall provide a functional description of the telecommunication subsystems for both fibre optic transmission system and Termination equipment system and a discussion of the failover and alternate routing schemes inherent in the configuration. The training shall include an overview of the network configuration and indicate the functional responsibilities of all major subsystems including the network monitoring system hardware and software. The training shall highlight all significant methodologies or concepts utilized by the hardware and software to perform the required functions. High-level hardware configuration block diagrams and network/sub-network block/flow diagrams shall be included to enhance the understanding of the overall capability incorporated into all network and sub-network equipment.

The training shall be oriented to a user’s point of view. The Employer/Owner users will include managers, design & planning personnel, communication support staff and maintenance personnel. As part of the proposal, the Contractor shall identify the number of days deemed appropriate for this training.

The overview training shall be customized for the specific functions, features, and equipment purchased by the Employer; it shall not be a general presentation of the Contractor’s standard
equipment repertoire. Personnel assigned by the Contractor to implement the Employer's system shall conduct this overview training. The Employer shall review and approve the contents of the overview training at least four (4) weeks prior to the course.

5.1.2 Installation & Maintenance Training

There shall be separate modules of the installation & maintenance training for the following systems:

1. FO Transmission System Training
2. Termination Equipment System Training

The installation & maintenance trainings shall enable the Employer to be self-sufficient in preventive & restorative maintenance of the respective communications subsystems purchased by the Employer.

5.1.3 Training Course Requirements

This section describes general requirements that apply to all training courses.

5.1.3.1 Class Size

The Employer plans to send a number of participants to the training courses for a specified duration as described in Appendices.

5.1.3.2 Training Schedule

The Contractor shall provide training in a timely manner that is appropriate to the overall project schedule. All training courses shall be available to the Employer for a minimum of five years after final acceptance of the communication system.

The training courses shall be offered in one cycle, such that none of the courses within the cycle overlap. The Contractor shall take the above requirements into account in developing the preliminary training schedule. Contractor shall develop a final training schedule in consultation with the Employer after contract award.

5.1.3.3 Manuals and Equipment

The Contractor, subcontractor, or OEM shall prepare training manuals and submit them to the Employer for review at least one month prior to the start of classroom instruction. The training manuals shall be prepared specifically for use as training aids; reference manuals, maintenance manuals, and user's manuals may be used as supplementary training material. Principal documents used for training shall be tailored to reflect all the Employer requirements specified.

Each course participant shall receive individual copies of training manuals and other pertinent material at least two weeks prior to the start of each course. The Employer shall retain the master and two additional copies of all training manuals and materials as reference documentation. A complete set of instructor's manuals and training aids shall also be provided.

Upon completion of each course, instructor's manuals, training manuals, and training aids shall become the property of the Employer. As part of the delivered system documentation and the final documentation, the Contractor shall supply the Employer with all changes and revisions to the training manuals and other training documentation. The Employer reserves the right to copy all training manuals and aids for use in the Employer-conducted training courses. The Contractor shall furnish for use during training courses all special tools, equipment, training aids, and any...
other materials required to train course participants.

5.2 Support Services

Throughout design, implementation, factory testing, and field installation and testing, the Contractor shall supply consulting assistance, as required by the Employer for site preparation, field installation, and other areas where technical support may be required.

The Contractor shall be responsible for minor facility renovation, and maintenance of the supplied system up to and including successful completion of the Site Acceptance Test.

After final acceptance of the communications equipment, the Contractor shall offer continuing technical support and spare parts for the designed life of the equipment or 7 years after the declaration of withdrawal of equipment from production whichever is earlier. However the termination of production shall not occur prior to Operational Acceptance of the system by the Employer. Some locations have existing SDH & MUX equipment. The traffic may be switched over to new fibre optic communication equipment in phase manner. The Contractor shall review the Employer existing equipment make, integration & switch over recommendation and prepare a detailed field implementation plan.

5.2.1 Technical Support

Consultation with Contractor's technical support personnel and trained field service personnel shall be readily available on a short-term/long-term basis to assist the Employer personnel in maintaining, expanding, and enhancing the telecommunication network upon expiration of the warranty period. The Contractor shall include in their offer(s), a proposal for ensuring continued technical support as stated above.

5.2.2 Contractor's Future Hardware/Software Changes

The Employer shall be informed of all alterations or improvements to the hardware supplied under this Specification. The Employer shall be placed on the Contractor's mailing list to receive announcements of the discovery, documentation, and solution of hardware/software problems as well as other improvements that could be made to supply equipment. The service shall begin at the time of contract award, and shall continue for 10 years. The Contractor shall also include a subscription to the hardware subcontractors' change notification service from the time of contract award through the warranty period, with a Employer renewable option for extended periods.

5.3 Spare Parts and Test Equipment

The spare parts and test equipment shall be provided for each subsystem as described below.

5.3.1 Mandatory Spare Parts

Appendices provides the Mandatory Spare Parts Requirements described in subsystem sets. The mandatory spare parts table represents the minimum spares the Contractor shall be required to supply. The subsystem set of spare parts is defined to include all equipment modules, subunits and parts required to effect replacement, repair and restoration to full operational status of a defined unit of a subsystem (i.e. SDH equipment, Primary Mux, Drop/Insert etc.)

5.4 System Maintenance

The contractor shall be responsible to maintain the confidentiality of the Employer’s System
Information that Employer shares with the contractor for maintenance period.

5.4.1 Warranty Period

The one year period commencing immediately after the operational acceptance is called the Warranty Period/Defect liability Period. In addition to the responsibilities covered under contract during Defect Liability Period, the Contractor shall also be responsible for maintenance of the Fibre Optic Transmission System, Termination Equipment, etc. supplied under this Package.

5.4.2 Contractor’s Maintenance Responsibility

The Contractor shall be responsible for carrying out “Comprehensive Maintenance” of the Communication System for a period of six years after warranty period for ensuring the successful operation of the system. The Contractor shall be responsible for achieving the system availability and the response time mentioned in technical specifications. The bidder shall quote the Annual Maintenance Charges for six years after Warranty Period which shall be considered in the bid evaluation. Bidder shall submit the detailed procedure for achieving above in the bid. Upon expiry of the six years AMC period Employer may, at its discretion, extend this Maintenance for additional one year at the same price & terms and conditions.

5.5 Miscellaneous Supplies

The Contractor shall provide all required consumable and non-consumable supplies necessary to support all installation and test activities through final operational acceptance. However, if there are any problems in the SAT and additional consumables are required, the same shall also be supplied by the Contractor at no additional cost.

5.6 Documentation

The Contractor shall submit following documents during detailed engineering:

(a) Data Requirement sheets
(b) Link Budget calculations
(c) MQP, FQP
(d) Bill of Quantity including mandatory spares
(e) Previous Type test reports
(f) Factory Test report
(g) Manuals for each equipment
(h) Schematic drawing
(i) Numbering, Marking, labelling document
(j) Synchronization plan
(k) Test schedule
(l) Training manual
(m) Configuration diagram
(n) Transportation & handling Procedure
(o) Installation Manuals
(p) Maintenance Manuals
FIBRE OPTIC BASED COMMUNICATION EQUIPMENTS

APPENDIX A

DATA REQUIREMENT SHEETS
Appendix-A

Data Requirement Sheets

The following sets of Data Requirement Sheets are required to be filled up by the bidders to aid in the evaluation process. The response shall be brief and to the point and shall be supported by the printed product description and other literature. The DRS duly filled and the relevant drawings shall also be submitted during the detailed engineering along with the relevant technical brochures.
DRS Form 01
DATA REQUIREMENTS SHEETS for
OPTICAL LINE TERMINATION EQUIPMENT (OLTE)

Manufacturer: ________________________________

Model #: ________________________________

GENERAL OLTE FEATURES

<table>
<thead>
<tr>
<th>Seq</th>
<th>Parameter:</th>
<th>As per Technical Specification</th>
<th>As per Bidder Offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>SDH hierarchy level: STM-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capacity Aggregate Bit-rate: 155 Mbps</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CEPT E-1 Ports: 63 x E1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Minimum No. of protected (MSP) directions</td>
<td>Two</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>No. of E1 ports in E1 tributary cards</td>
<td>minimum 16</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>No. of Ethernet ports in Ethernet interface tributary cards</td>
<td>minimum 4</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Service Channel provision</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Voice Channel</td>
<td>Minimum 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Data Channel</td>
<td>Minimum 1</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Power Supply cards of SDH equipment</td>
<td>1:1 APS or distributed power supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Common Control* Card of SDH equipment</td>
<td>1:1 APS</td>
<td></td>
</tr>
</tbody>
</table>

* = Common Control Cards which are essentially required for the operation of the equipment
DRS Form 02
DATA REQUIREMENTS SHEETS for
Primary Multiplexer/Drop & Insert Multiplexer

Manufacturer:
________________________________________

Model #:
________________________________________

Configuration:

<table>
<thead>
<tr>
<th>Seq.</th>
<th>Parameter</th>
<th>As per Technical Specification</th>
<th>As per Bidder Offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Output Aggregate Rate</td>
<td>2.048 Mbps +/- 50 ppm</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Interface Code</td>
<td>HDB3</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Impedance</td>
<td>75 ohm unbalanced</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Maximum Insertion Loss</td>
<td>6 dB</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Power Supply card of multiplexer</td>
<td>1:1 APS or distributed power supply</td>
<td></td>
</tr>
</tbody>
</table>

The detailed DRS for all equipments/items are required to be submitted along with brochures during detailed engineering.
# CHAPTER 19: TRANSFORMER & REACTOR

## Contents

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1.0 FOREWORD

1.1 The provisions under this Chapter are intended to supplement general requirements for the materials, equipment’s and services covered under other Chapters of tender documents and is not exclusive. However in case of conflict between the requirements specified in this Chapter and requirements specified under other Chapters, the requirements specified under respective Chapters shall prevail.

2.0 GENERAL REQUIREMENT

2.1 The bidders shall submit the technical requirements, data and information as per the technical data sheets provided in the bid documents.

2.2 The bidders shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification. An indicative list of such drawings and documents for transformer and reactor are enclosed in Annexure-A.

2.3 It is recognised that the Contractor may have standardised on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer’s standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to the Purchaser. Unless brought out clearly, the Bidder shall be deemed to conform to this specification scrupulously. All deviations from the specification shall be clearly brought out in the respective schedule of deviations. Any discrepancy between the specification and the catalogues or the bid, if not clearly brought out in the specific requisite schedule, will not be considered as valid deviation.

2.4 Wherever a material or article is specified or defined by the name of a particular brand, Manufacturer or Vendor, the specific name mentioned shall be understood as establishing type, function and quality and not as limiting competition.

2.5 Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification but which are necessary for commissioning and satisfactory operation of the equipment unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

3.0 STANDARDS

3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of Nepal.

3.2 The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the date of bid opening) of standard specified under Annexure-B of this Chapter, unless specifically mentioned in the specification.

3.3 The Bidder shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.
3.4 The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific IEC/CIGRE/IEEE/NEMA.

3.5 When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.

3.6 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Annexure B / individual Chapters for various equipments shall also, be accepted, however the salient points of difference shall be clearly brought out in additional information schedule along with English language version of such standard. The equipment conforming to standards other than specified under Annexure B / individual Chapters for various equipments shall be subject to Purchaser’s approval.

3.7 The bidder shall clearly indicate in his bid the specific standards in accordance with which the works will be carried out.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

4.1 All equipment shall perform satisfactorily under various electrical, electromechanical and meteorological conditions of the site of installation.

4.2 All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) short circuit etc for the equipment.

4.3 The equipment shall also comply to the following:

4.4 a) To facilitate erection of equipment, all items to be assembled at site shall be “match marked”.

b) All piping, if any between equipment control cabinet/ operating mechanism to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.

4.5 EHV equipments and system shall be designed to meet the following major technical parameters as brought out hereunder.

4.5.1 System Parameter

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of parameters</th>
<th>220 KV System</th>
<th>132 KV System</th>
<th>33 KV System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>System operating voltage</td>
<td>220KV</td>
<td>132KV</td>
<td>33KV</td>
</tr>
<tr>
<td>2.</td>
<td>Maximum system operating voltage (rms), Um</td>
<td>245KV</td>
<td>145KV</td>
<td>36KV</td>
</tr>
<tr>
<td>3.</td>
<td>Rated frequency</td>
<td>50Hz</td>
<td>50Hz</td>
<td>50Hz</td>
</tr>
<tr>
<td>4.</td>
<td>No. of phase</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>Rated Insulation levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Full wave impulse withstand voltage(1.2/50 micro sec.)</td>
<td>1050KVp</td>
<td>650KVp</td>
<td>170KVp</td>
</tr>
<tr>
<td></td>
<td>iii) One minute power frequency dry and wet withstand voltage (rms)</td>
<td>460KV</td>
<td>275KV</td>
<td>70KV</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>6.</td>
<td>Corona extinction voltage</td>
<td>156KV</td>
<td>105KV</td>
<td>-</td>
</tr>
<tr>
<td>7.</td>
<td>Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 508kV rms for 765kV, 320kV rms for 400kV system and 156kV rms for 220kV system &amp; 92 kV rms for 132kV system</td>
<td>1000 micro-volt</td>
<td>500 micro-volt</td>
<td>-</td>
</tr>
<tr>
<td>8.</td>
<td>Minimum creepage distance</td>
<td>25 mm/KV (6125 mm)</td>
<td>25 mm/KV (3625 mm)</td>
<td>25 mm/KV (900 mm)</td>
</tr>
<tr>
<td>9.a</td>
<td>Min. clearances in air for Transformer &amp; Reactor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>Phase to phase</td>
<td>2300 mm (for BIL-950 kVp)</td>
<td>1220 mm (for BIL-550 kVp)</td>
<td>350 mm (for BIL-170 kVp)</td>
</tr>
<tr>
<td>ii.</td>
<td>Phase to earth</td>
<td>1800 mm (for BIL-950 kVp)</td>
<td>1050 mm (for BIL-550 kVp)</td>
<td>320mm (for BIL-170 kVp)</td>
</tr>
<tr>
<td>9.b</td>
<td>Min. clearances in air for other switchyard equipments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Phase to phase</td>
<td>2100 mm</td>
<td>1300 mm</td>
<td>320 mm</td>
</tr>
<tr>
<td>ii)</td>
<td>Phase to earth</td>
<td>2100 mm</td>
<td>1300 mm</td>
<td>320 mm</td>
</tr>
<tr>
<td>iii)</td>
<td>Sectional clearances</td>
<td>5000 mm</td>
<td>4000 mm</td>
<td>3000 mm</td>
</tr>
<tr>
<td>10.</td>
<td>Rated short circuit current for 1 sec. duration</td>
<td>40 kA</td>
<td>31.5 kA</td>
<td>25 kA</td>
</tr>
<tr>
<td>11.</td>
<td>System neutral earthing</td>
<td>Effectively earthed</td>
<td>Effectively earthed</td>
<td>Effectively earthed</td>
</tr>
</tbody>
</table>

Note: The insulation and RIV levels of the equipments shall be as per values given in the respective chapter of the equipments.
5.0 **ENGINEERING DATA AND DRAWINGS**

5.1 The engineering data shall be furnished by the Contractor in accordance with the Schedule for each set of equipment as specified in the Technical Specifications.

5.2 The list of drawings/documents which are to be submitted to the Purchaser shall be discussed and finalised by the Purchaser at the time of award.

The Contractor shall necessarily submit all the drawings/documents unless anything is waived.

5.3 Drawings

5.4 All drawings submitted by the Contractor including those submitted at the time of bid shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal & the external connections, fixing arrangement required and any other information specifically requested in the specifications.

5.4.1 Each drawing submitted by the Contractor shall be clearly marked with the name of the Purchaser, the unit designation, the specifications title, the specification number and the name of the Project. If standard catalogue pages are submitted, the applicable items shall be indicated therein. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in metric units.

5.4.2 Further work by the Contractor shall be in strict accordance with these drawings and no deviation shall be permitted without the written approval of the Purchaser, if so required.

5.5 The review of these data by the Purchaser will cover only general conformance of the data to the specifications and documents, interfaces with the equipment provided under the specifications, external connections and of the dimensions which might affect substation layout. This review by the Purchaser may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the information submitted. This review and/or approval by the Purchaser shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and documents.

5.6 All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawings shall be at the Contractor’s risk. The Contractor may make any changes in the design which are necessary to make the equipment conform to the provisions and intent of the Contract and such changes will again be subject to approval by the Purchaser. Approval of Contractor’s drawing or work by the Purchaser shall not relieve the contractor of any of his responsibilities and liabilities under the Contract.

5.7 All engineering data submitted by the Contractor after final process including review and approval by the Purchaser shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Purchaser in Writing.

5.8 Approval Procedure

The scheduled dates for the submission of the drawings as well as for, any data/information to be furnished by the Purchaser would be discussed and finalised at the time of award. The following schedule shall be followed generally for approval and for providing final documentation.
i) Approval/comments/ by Purchaser on initial submission
   As per agreed schedule

ii) Resubmission
    (whenever required)
    Within 4 (four) weeks from date of comments including both ways postal time.

iii) Approval or comments of resubmission.
     Within 4 weeks of receipt

iv) Furnishing of distribution copies in bound volume
    (5 copies per substation and one copy for Corporate office of Owner)
    3 weeks from the date of final approval

v) Furnishing of distribution copies of test reports
   (a) Type test reports
       (one copy per substation plus one copy for corporate office of Owner)
       3 weeks from the date of final approval
   (b) Routine Test Reports
       (one copy for each substation)
       -do-

vi) Furnishing of instruction/
    operation manuals (4 copies per substation and two copies for corporate office of Owner)
    As per agreed schedule

(vii) Visual Compact Disk (VCD)
     highlighting installation and maintenance techniques/
     requirements of transformer & reactor
     (one per substation plus one for corporate office of Owner)
     -do-

(viii) As built drawings on CD/optical Disc (Two sets per substation plus one set for corporate office of Owner)
      On completion of entire works

NOTE:
(1) The contractor may please note that all resubmissions must incorporate all comments given in the earlier submission by the Purchaser or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.

(2) The drawings which are required to be referred frequently during execution should be submitted on cloth lined paper or Laminated Sheets. The list of such drawings shall be finalised with the Contractor at the time of Award.
(3) All major drawings should be submitted in Auto Cad Version 2000 or better.

(4) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.

(5) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Purchaser.

(6) The Contractor shall furnish to the Purchaser catalogues of spare parts.

6.0 MATERIAL/ WORKMANSHP

6.1 General Requirement

6.1.1 Where the specification does not contain reference to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.

6.1.2 In case where the equipment, materials or components are indicated in the specification as "similar" to any special standard, the Purchaser shall decide upon the question of similarity. When required by the specification or when required by the Purchaser the Contractor shall submit, for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Contractor.

6.1.3 The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the Purchaser.

6.1.4 Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.

6.1.5 All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless otherwise specified, shall include unpacking, cleaning and lifting into position, grouting,
leveling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer’s tolerances, instructions and the Specification. All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer’s limits suitable guards shall be provided for the protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

6.1.6 The Contractor shall apply oil and grease of the proper specification to suit the machinery, as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary for applying the lubricant required for operation. The Contractor shall apply all operational lubricants to the equipment installed by him.

6.1.7 All oil, grease and other consumables used in the Works/ Equipment shall be purchased in Nepal unless the Contractor has any special requirement for the specific application of a type of oil or grease not available in Nepal. In such is the case he shall declare in the proposal, where such oil or grease is available. He shall help Purchaser in establishing equivalent Nepal make and Nepal Contractor. The same shall be applicable to other consumables too.

6.1.8 A cast iron or welded steel base plate shall be provided for all rotating equipment which are to be installed on a concrete base unless otherwise agreed to by the Purchaser. Each base plate shall support the unit and its drive assembly, shall be of design with pads for anchoring the units, shall have a raised up all around and shall have threaded in air connections, if so required.

6.2 Provisions for Exposure to Hot and Humid climate

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

6.2.1 Space Heaters

6.2.1.1 The heaters shall be suitable for continuous operation at 230 V AC supply voltage. On-off switch and fuse shall be provided.

6.2.1.2 One or more adequately rated thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the compartment and electrical connections shall be made sufficiently away from below the heaters to minimize deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature to prevent condensation.

6.2.1.3 Suitable anti condensation heaters with the provision of thermostat shall be provided.

6.2.2 FUNGI STATIC VARNISH

Besides the space heaters, special moisture and fungus resistant varnish shall be applied on parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface of part where the treatment will interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

6.2.3 Ventilation opening
Wherever ventilation is provided, the compartments shall have ventilation openings
with fine wire mesh of brass to prevent the entry of insects and to reduce to a
minimum the entry of dirt and dust. Outdoor compartment openings shall be
provided with shutter type blinds and suitable provision shall be made so as to
avoid any communication of air / dust with any part in the enclosures of the Control
Cabinets, Junction boxes and Marshalling Boxes, panels etc.

6.2.4 Degree of Protection
The enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes,
panels etc. to be installed shall provide degree of protection as detailed here under:
a) Installed out door: IP- 55
b) Installed indoor in air conditioned area: IP-31
c) Installed in covered area: IP-52
d) Installed indoor in non air conditioned area where possibility of entry of water
   is limited: IP-41.

The degree of protection shall be in accordance with IEC-947 (Part-I)/ IEC 529.
Type test report for degree of protection test, on each type of the box shall be
submitted for approval.

6.3 RATING PLATES, NAME PLATES AND LABELS
6.3.1 Each main and auxiliary item of substation is to have permanently attached to it in a
conspicuous position a rating plate of non-corrosive material upon which is to be
engraved manufacturer’s name, year of manufacture, equipment name, type or
serial number together with details of the loading conditions under which the item of
substation in question has been designed to operate, and such diagram plates as
may be required by the Purchaser. The rating plate of each equipment shall be
according to IEC requirement.

6.3.2 All such nameplates, instruction plates, rating plates of transformers & reactors
shall be bilingual with Hindi inscription first followed by English. Alternatively two
separate plates one with Hindi and the other with English inscriptions may be
provided.

6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS
All the first fill of consumables such as oils, lubricants, filling compounds, touch up
paints, soldering/brazing material for all copper piping of circuit breakers and
essential chemicals etc. which will be required to put the equipment covered under
the scope of the specifications, into successful Operation, shall be furnished by the
Contractor unless specifically excluded under the exclusions in these specifications
and documents.

7.0 DESIGN IMPROVEMENTS / COORDINATION

7.1 The bidder shall note that the equipment offered by him in the bid only shall be
accepted for supply. However, the Purchaser or the Contractor may propose
changes in the specification of the equipment or quality thereof and if the Purchaser
& contractor agree upon any such changes, the specification shall be modified
accordingly.

7.2 If any such agreed upon change is such that it affects the price and schedule of
completion, the parties shall agree in writing as to the extent of any change in the
price and/or schedule of completion before the Contractor proceeds with the
change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

7.3 The Contractor shall be responsible for the selection and design of appropriate equipments to provide the best coordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

7.4 The Contractor has to coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Purchaser. The names of agencies shall be intimated to the successful bidders.

7.5 The Contractor will be called upon to attend design co-ordination meetings with the Engineer, other Contractor’s and the Consultants of the Purchaser (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at Corporate Office of Owner, Nepal or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

8.0 QUALITY ASSURANCE PROGRAMME

8.1 To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Contractor's Works or at his Sub-contractor's premises or at the Purchaser's site or at any other place of Work are in accordance with the specifications, the Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be broadly outlined by the contractor and finalised after discussions before the award of contract. The detailed programme shall be submitted by the contractor after the award of contract and finally accepted by OWNER after discussion. However, in case detailed valid programme approved by OWNER for the equipment already exist, same would be followed till its validity. A quality assurance programme of the contractor shall generally cover the following:

(a) His organisation structure for the management and implementation of the proposed quality assurance programme;
(b) Documentation control system;
(c) Qualification data for bidder’s key personnel;
(d) The procedure for purchases of materials, parts components and selection of sub-Contractor’s services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
(e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;
(f) Control of non-conforming items and system for corrective actions;
(g) Inspection and test procedure both for manufacture and field activities.
(h) Control of calibration and testing of measuring instruments and field activities;
(i) System for indication and appraisal of inspection status;
(j) System for quality audits;
(k) System for authorising release of manufactured product to the Purchaser.
(l) System for maintenance of records;
(m) System for handling storage and delivery; and
(n) A quality plan detailing out the specific quality control measures and procedures adopted for controlling the quality characteristics relevant to each item of equipment furnished and/or services rendered.

The Purchaser or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and procedure of the Contractor/his vendor’s quality management and control activities.

8.2 Quality Assurance Documents

The contractor would be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of purchaser’s inspection of equipment/material

9.0 TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

9.1 All equipment being supplied shall conform to type tests including additional type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective Chapters. Purchaser reserves the right to witness any or all the tests. The Contractor shall intimate the Purchaser the detailed program about the tests atleast three (3) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

9.2 The reports for all type tests and additional type tests as per technical specification shall be furnished by the Contractor alongwith equipment / material drawings. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by the representative(s) of OWNER or Utility/third party.

In the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design / manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all additional type tests not carried out, same shall be carried out without any additional cost implication to the Purchaser.

9.3 The Purchaser intends to repeat the type tests and additional type tests on transformers & reactor for which test charges shall be payable as per provision of contract. The price of conducting type tests and additional type tests shall be included in Bid price and break up of these shall be given in the relevant schedule of Bid Proposal Sheets. These Type test charges would be considered in bid evaluation. In case Bidder does not indicate charges for any of the type tests or does not mention the name of any test in the price schedules, it will be presumed that the particular test has been offered free of charge. Further, in case any Bidder indicates that he shall not carry out a particular test, his offer shall be considered incomplete and shall be liable to be rejected.

9.4 The Purchaser, his duly authorised representative and/or outside inspection agency acting on behalf of the Purchaser shall have at all reasonable times free access to the Contractor’s/sub-vendors premises or Works and shall have the power at all reasonable times to inspect and examine the materials and workmanship of the Works during its manufacture or erection if part of the Works is being manufactured or assembled at other premises or works, the Contractor shall obtain for the Engineer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor’s own premises or works. Inspection may be made at any stage of manufacture, despatch or at site at
the option of the Purchaser and the equipment if found unsatisfactory due to bad
workmanship or quality, material is liable to be rejected.

9.5 The Contractor shall give the Purchaser /Inspector thirty (30) days written notice of
any material being ready for joint testing including contractor and **Owner**. Such
tests shall be to the Contractor’s account except for the expenses of the Inspector.
The Purchaser /inspector, unless witnessing of the tests is virtually waived, will
attend such tests within thirty (30) days of the date of which the equipment is
notified as being ready for test/inspection, failing which the Contractor may proceed
alone with the test which shall be deemed to have been made in the Inspector’s
presence and he shall forthwith forward to the Inspector duly certified copies of
tests in triplicate.

9.6 The Purchaser or Inspector shall, within fifteen (15) days from the date of
inspection as defined herein give notice in writing to the Contractor, of any objection
to any drawings and all or any equipment and workmanship which in his opinion is
not in accordance with the Contract. The Contractor shall give due consideration to
such objections and shall either make the modifications that may be necessary to
meet the said objections or shall confirm in writing to the Purchaser /Inspector
giving reasons therein, that no modifications are necessary to comply with the
Contract.

9.7 When the factory tests have been completed at the Contractor’s or Sub-
Contractor’s works, the Purchaser/inspector shall issue a certificate to this effect
within fifteen (15) days after completion of tests but if the tests are not witnessed by
the Purchaser /Inspector, the certificate shall be issued within fifteen (15) days of
receipt of the Contractor’s Test certificate by the Engineer/Inspector. Failure of the
Purchaser /Inspector to issue such a certificate shall not prevent the Contractor
from proceeding with the Works. The completion of these tests or the issue of the
certificate shall not bind the Purchaser to accept the equipment should, it, on further
tests after erection, be found not to comply with the Contract. The equipment shall
be dispatched to site only after approval of test reports and issuance of CIP by the
Purchaser.

9.8 In all cases where the Contract provides for tests whether at the premises or at the
works of the Contractor or of any Sub-Contractor, the Contractor except where
otherwise specified shall provide free of charge such items as labour, materials,
electricity, fuel, water, stores, apparatus and instruments as may be reasonably
demanded by the Purchaser /Inspector or his authorised representative to carry out
effectively such tests of the equipment in accordance with the Contract and shall
give facilities to the Purchaser /Inspector or to his authorised representative to
accomplish testing.

9.9 The inspection by Purchaser and issue of Inspection Certificate thereon shall in no
way limit the liabilities and responsibilities of the Contractor in respect of the agreed
quality assurance programme forming a part of the Contract.

9.10 The Purchaser will have the right of having at his own expenses any other test(s) of
reasonable nature carried out at Contractor’s premises or at site or in any other
place in addition of aforesaid type and routine tests, to satisfy that the material
comply with the specification.

9.11 The Purchaser reserves the right for getting any field tests not specified in
respective Chapters of the technical specification conducted on the completely
assembled equipment at site. The testing equipments for these tests shall be
provided by the Purchaser.
10.0 TESTS

10.1 Pre-commissioning Tests
On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Purchaser and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The list of pre-commissioning tests to be performed are given in respective chapters and shall be included in the Contractor’s quality assurance programme.

10.2 Commissioning Tests

10.2.1 The available instrumentation and control equipment will to be used during such tests and the Purchaser will calibrate, all such measuring equipment and devices as far as practicable.

10.2.2 Any special equipment, tools and tackles required for the successful completion of the Commissioning Tests shall be provided by the Contractor, free of cost.

10.2.3 The specific tests requirement on equipment have been brought out in the respective chapters of the technical specification.

10.3 The Contractor shall be responsible for obtaining statutory clearances from the concerned authorities for commissioning the equipment. However necessary fee shall be reimbursed by Owner on production of requisite documents.
11.0 PACKAGING & PROTECTION

11.1 All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. On request of the Purchaser, the Contractor shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Purchaser to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes should be taken into account. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharf age and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor. Purchaser takes no responsibility of the availability of the wagons.

11.2 All coated surfaces shall be protected against abrasion, impact, discoloration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

12.0 FINISHING OF METAL SURFACES

12.1 All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed, shall be hot-dip galvanized after fabrication. High tensile steel nuts & bolts and spring washers shall be electro galvanized to service condition 4. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized according to equivalent international standards.

13.0 HANDLING, STORING AND INSTALLATION

13.1 In accordance with the specific installation instructions as shown on manufacturer’s drawings or as directed by the Purchaser or his representative, the Contractor shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energisation at rated voltage.

13.2 Contractor may engage manufacturer’s Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Contractor shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer’s supervisory Engineer(s) and shall extend full cooperation to them.

13.3 In case of any doubt/misunderstanding as to the correct interpretation of manufacturer’s drawings or instructions, necessary clarifications shall be obtained from the Purchaser. Contractor shall be held responsible for any damage to the equipment consequent to not following manufacturer’s drawings/instructions correctly.

13.4 Where assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against
damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense.

13.5 Contractor shall be responsible for examining all the shipment and notify the Purchaser immediately of any damage, shortage, discrepancy etc. for the purpose of Purchaser’s information only. The Contractor shall submit to the Purchaser every week a report detailing all the receipts during the weeks. However, the Contractor shall be solely responsible for any shortages or damages in transit, handling and/or in storage and erection of the equipment at Site. Any demurrage, wharf age and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

13.6 The Contractor shall be fully responsible for the equipment/material until the same is handed over to the Purchaser in an operating condition after commissioning. Contractor shall be responsible for the maintenance of the equipment/material while in storage as well as after erection until taken over by Purchaser, as well as protection of the same against theft, element of nature, corrosion, damages etc.

13.7 Where material / equipment is unloaded by Purchaser before the Contractor arrives at site or even when he is at site, Purchaser by right can hand over the same to Contractor and there upon it will be the responsibility of Contractor to store the material in an orderly and proper manner.

13.8 The Contractor shall be responsible for making suitable indoor storage facilities, to store all equipment which require indoor storage.

13.9 The words ‘erection’ and ‘installation’ used in the specification are synonymous.

13.10 Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.

13.11 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 4.4.1 the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.

13.12 Equipment Bases

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base unless otherwise agreed to by the Purchaser. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

14.0 SPECIAL TOOLS AND TACKLES

The Contractor shall supply with the equipment one complete set of all special tools and tackles for the erection, assembly, dis-assembly and maintenance of the equipment which are proprietary in nature. However, these tools and tackles shall be separately, packed and brought on to Site.
15.0 **AUXILIARY SUPPLY**

15.1 The sub-station auxiliary supply is normally met through a system having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under.

<table>
<thead>
<tr>
<th>Normal Voltage</th>
<th>Variation in Voltage</th>
<th>Frequency in HZ</th>
<th>Phase / Wire</th>
<th>Neutral connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>400V</td>
<td>+/- 10%</td>
<td>50 +/- 5%</td>
<td>3/ Wire</td>
<td>Solidly Earthed.</td>
</tr>
<tr>
<td>230V</td>
<td>+/- 10%</td>
<td>50 +/- 5%</td>
<td>1/ Wire</td>
<td>Solidly Earthed.</td>
</tr>
</tbody>
</table>

Combined variation of voltage and frequency shall be limited to +/- 10%.

16.0 **CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES & MARSHALLING BOXES FOR OUTDOOR EQUIPMENT**

16.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IEC-439 and the clauses given below:

16.2 Control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of sheet steel or aluminum enclosure and shall be dust, water and vermin proof. Sheet steel used shall be at least 2.0 mm thick cold rolled or 2.5 mm hot rolled. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.

16.3 Cabinet/boxes shall be free standing floor mounting type, wall mounting type or pedestal mounting type as per requirements. A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.

16.4 Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/ cracked during the operation of the equipment.

16.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM gaskets. The gasket shall be tested in accordance with approved quality plan. The quality of gasket shall be such that it does not get damaged/ cracked during the ten years of operation of the equipment or its major overhaul whichever is earlier. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion and to make a tight seal. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.

16.6 All boxes/cabinets shall be designed for the entry of cables from bottom by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from...
below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate projecting at least 150 mm above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. The gland shall project at least 25 mm above gland plate to prevent entry of moisture in cable crutch. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS:6121.

16.7 A 230V, single phase, 50 Hz, 15 amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.

16.8 For illumination of a 20 Watts fluorescent tube or 15 watts CFL shall be provided. The switching of the fittings shall be controlled by the door switch.

16.9 All control switches shall be of rotary switch type and Toggle/piano switches shall not be accepted.

16.10 Positive earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self etching washer. Earthing of hinged door shall be done by using a separate earth wire.

16.11 The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.

16.12 a) The following routine tests alongwith the routine tests shall also be conducted:
   i) Check for wiring
   ii) Visual and dimension check

b) The enclosure of bay marshalling kiosk, junction box, terminal box shall conform to IP-55 including application of, 2.5 KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test.

17.0 SUPPORT STRUCTURE

17.1 The support structures to be supplied by the contractor for the tertiary arrangement should be hot dip galvanised with minimum 610 gram/sq.m net of zinc.

17.2 Support structure shall meet the following mandatory requirements:

17.3 The minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 metres.

18.0 TERMINAL BLOCKS AND WIRING

18.1 Control and instrument leads from the switchboards or from other equipment will be brought to terminal boxes or control cabinets in conduits. All interphase and external connections to equipment or to control cubicles will be made through terminal blocks.

18.2 Terminal blocks shall be 650 V grade and have continuous rating to carry the maximum expected current on the terminals. These shall be of moulded piece,
complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. The terminal blocks shall be non-disconnecting stud type equivalent to Elmex type CATM4, Phoenix (cage clamp type), Wago or equivalent.

18.3 Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short circuiting and earthing facilities.

18.4 The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have a locking characteristic to prevent cable from escaping from the terminal clamp unless it is done intentionally.

18.5 The conducting part in contact with cable shall preferably be tinned or silver plated however Nickel plated copper or zinc plated steel shall also be acceptable.

18.6 The terminal blocks shall be of extensible design.

18.7 The terminal blocks shall have locking arrangement to prevent its escape from the mounting rails.

18.8 The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barriers shall be provided between the terminal blocks. These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.

18.9 Unless otherwise specified terminal blocks shall be suitable for connecting the following conductors on each side.

   a) All circuits except CT circuits Minimum of two of 2.5 sq mm copper flexible.

   b) All CT circuits Minimum of 4 nos. of 2.5 sq mm copper flexible.

18.10 The arrangements shall be in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.
18.11 The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets. For equipments rated for 400 kV and above the wiring required in these items shall be run in metallic ducts or shielded cables in order to avoid surge overvoltages either transferred through the equipment or due to transients induced from the EHV circuits.

18.12 All input and output terminals of each control cubicle shall be tested for surge withstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment.

19.0 LAMPS AND SOCKETS

19.1 Lamps
All incandescent lamps shall use a socket base as per IEC, except in the case of signal lamps.

19.2 Sockets
All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round Standard plugs. They shall be switched sockets with shutters.

19.3 Hand Lamp:
A 230 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

19.4 Switches and Fuses:
19.4.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.

19.4.2 All fuses shall be of HRC cartridge type mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

20.0 Bushings, Hollow Column Insulators, Support Insulators:

20.1 Bushings shall be manufactured and tested in accordance with IEC: 60137 while hollow column insulators shall be manufactured and tested in accordance with IEC 233. The support insulators shall be manufactured and tested as per IEC 168 and IEC 273. The insulators shall also conform to IEC 815 as applicable.
The bidder may also offer composite silicon rubber insulator, conforming to IEC-1109.

20.2 Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified tough and impervious to moisture.

20.3 Glazing of the porcelain shall be uniform brown in colour, free from blisters, burrs and similar other defects.

20.4 Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

20.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.

20.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

20.7 All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

20.8 Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with International Standards. The type test reports shall be submitted for approval.
Annexure –A

INDICATIVE LIST OF DRAWINGS FOR TRANSFORMER & REACTOR

1. Outline General Arrangement (OGA) drawing of transformer & reactor
   a) Plan
   b) Elevation
   c) End View
   d) Neutral formation of three phase bank
   List of all accessories with detailed weights, dimensions, clearances, spacing of wheels in direction, center of gravity, location of cooler etc.

2. Foundation Plan showing reaction at points of support, clamping arrangement & location of jacking pads.

3. Technical Data requirement sheet of transformer & reactor

4. Over fluxing withstand duration curve

5. Schematic wiring and diagram of cooling arrangement along with write up on scheme

6. Schematic wiring and diagram of OLTC along with write up on scheme

7. Mounting Arrangement and wiring diagram of remote WTI along with write up

8. Bushing Drawing showing electrical and mechanical characteristics
   a) HV Bushing
   b) LV Bushing
   c) Neutral bushing

9. Outline and General Arrangement of Cooler Control Cabinet

10. Cooler Control cabinet schematic and wiring diagram

11. Magnetisation Characteristics of bushing CTs

12. Hysteresis Characteristics of iron core

13. Rating and Diagram Plate

14. Overall Transport dimension Drawing of transformer & reactor

15. Drawing showing typical sectional view of the windings with details of insulation, cooling circuit method of cooling and core construction etc.

16. Oil Flow Diagram

17. Valve Schedule Plate drawing

18. Twin Bi-directional Roller

19. Connection Diagram of all protective devices to marshalling box showing physical location

20. List of spares

21. Technical Literature on all fittings and accessories.

22. Calculation to support short circuit withstand capacity of transformer & reactor

23. Calculation of hot spot temperature

24. Value of air core reactance with a typical write-up of calculation

25. Oil sampling Bottle details

26. Typical heating and cooling curves

27. OGA of RTCC panel

28. RTCC panel schematic and wiring diagram

29. Outline and General Arrangement drawing of Common Marshalling Box

30. Schematic wiring and diagram of Common Marshalling Box

31. OGA of Ladder for transformer & Reactor

32. Transformer oil storage tank drawing

33. 33 KV Neutral CT drawing and technical data sheet

34. Customer inspection schedule

35. Test procedure of transformer & reactor

36. Type test Reports of transformer & reactor

37. O & M manual of transformer & reactor

ANNEXURE - B
LIST OF SPECIFICATIONS

GENERAL STANDARDS AND CODES

IEC-60 (Part 1 to P4) - High Voltage Test Techniques
IEC 66 - Environmental Test
IEC-117 - Graphical Symbols
IEC-270, - Partial Discharge Measurements.
IEC-376 - Specification and Acceptance of New Sulphur Hexafluoride
IEC-437 - Radio Interference Test on High Voltage Insulators.
IEC-506, - Switching Impulse Tests on High Voltage Insulators.
IEC-507 - Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-6094 - Common Specification for High Voltage Switchgear & Control gear Standards.
IEC-865 (P1 & P2) - Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70 - National Electrical Code
ANSI-C63.21, - Specification for Electromagnetic Noise and C63.3 - Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1 - Techniques for Dielectric Tests
ANSI-C76.1/EEE21 - Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4 - Specification for Sound Level Meters
ANSI-Y32-2/C337.2 - Drawing Symbols
ANSI-Z55.11 - Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T - Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II - General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1 - Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h - Quality Assurance Program Requirements
CSA-Z299.2-1979h - Quality Control Program Requirements
CSA-Z299.3-1979h - Quality Verification Program Requirements
CSA-Z299.4-1979h - Inspection Program Requirements
TRANSFORMERS & REACTORS

IEC 60076
IEC 60076-1
IEC 60076-2
IEC 60076-3
IEC 60076-4
IEC 60076-3-1
IEC 60076-5
IEC 60076-6
IEC 60076-7
IEC 60076-8
IEC 60076-10
IEC 60076-10-1
IEC 60076-11
IEC 60076-12
IEC 60076-13
IEC 60076-14
IEC 60076-15
IEC 60076-16
IEC 60076-18
IEC 60076-19
IEC 60076-21
IEC 60044
IEC 60050
IEC 60050(421)
IEC 60060
IEC 60060-1
IEC 60060-2
IEC 60071
IEC 60071-1
IEC 60071-2
IEC 60137
IEC 60214
IEC 60270
IEC 60296
IEC 60422
IEC 60475
IEC 60529

Power transformers
Part 1: General
Part 2: Temperature rise
Part 3: Insulation levels, dielectric tests and external clearances in air
Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
Part 3-1: Insulation Levels and Dielectric Tests – External Clearances in Air
Part 5: Ability to withstand short circuit
Part 6: Reactors
Part 7: Loading guide for oil-immersed power transformers
Part 8: Application guide
Part 10: Determination of sound levels
Part 10-1: Determination of sound levels - Application guide
Part 11: Dry-type transformers
Part 12: Loading guide for dry-type power transformers
Part 13: Self-protected liquid-filled transformers
Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials
Part 15: Gas-filled power transformers
Part 16: Transformers for wind turbine applications
Part 18: Measurement of frequency response
Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors
Part 21: Standard requirements, terminology, and test code for step-voltage regulators
Current transformers
International Electrotechnical Vocabulary
International Electrotechnical vocabulary - Chapter 421 : Power Transformers and Reactors
High Voltage test techniques
General definitions and test requirements
Measuring systems
Insulation co-ordination
Part 1: Definitions, principles and rules
Part 2 : Application guide
Bushing for alternating voltage above 1000V
On-Load Tap changers
Relays vibration
Partial discharge measurements
Specification for Unused Mineral Oil for Transformers and Switchgear
Supervision and Maintenance guide for Mineral Insulating Oil in Electrical Equipment
Method of Sampling Liquid dielectrics
Classification of Degrees of Protection provided by
Enclosures

IEC 60542 Application Guide for On-Load Tap-Changers
IEC 60567 Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment for the Analysis of Free and Dissolved Gases
IEC 60651 Sound Level Meters
IEC 61083 Digital Recorders and Software for High Voltage Impulse testing
IEC 61083-1 Part 1: Requirements for digital recorders in high voltage impulse tests
IEC 61083-2 Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms
CISPR 16 Specification for radio disturbance and immunity measuring apparatus
CISPR 16-1 Radio disturbance and immunity measuring apparatus
CISPR-18 Radio Interference Characteristics of Power Lines and High Voltage Equipment
ISO 9001 Quality system-Model for Quality Assurance in Design /development
Cigre Publication 202 Guidelines for conducting design reviews for transformers 100 MVA and 123 kV and above. August 2002-Cigre Working Group 12.22
WG 12-15 Guide for Customers Specifications for Transformers 100 MVA and 123 kV and above
WG 12 19 Short Circuit Performance of Transformers.
BS-4360 Specification for weldable structural steel
BS-5135 Specification for arc welding of carbon and carbon manganese steels
BS-5500 Specification for unfired fusion welded pressure vessels
ISO-8501 Preparation of steel surface before application of Paints and related product
IEC-60599 Mineral oil impregnated electrical equipment in service – guide to the interpretation of dissolved and free gases analysis
IEC-60034-5 Degrees of protection provided by integral design of rotating electrical machines(IP Code) classification
IEC-62271-203 Gas insulated metal enclosed switchgear for rated voltage above 52kV
IEC-61639 Direct connection between power transformers and gas-insulated metal enclosed switchgear for rated voltages of 52.5 kV and above.
IEC 60529 / IP : 55 Degree of protection for cooler control cabinet , MOLG , Cooling fan , oil pump, Buchholz Relay
IEC 60529 / IP : 56 Degree of protection for Pressure Relief Device
IEC 60529 / IP : 43 Degree of protection for Remote tap Changer cubicle (RTCC)

Clamps & connectors

NEMA-CC1 - Electric Power connectors for sub station
NEMA-CC 3 - Connectors for Use between aluminium or aluminum-Copper Overhead Conductors
Wires and cables

**ASTMD-2863** - Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)

**IEC-96 (part 0 to p4)** - Radio Frequency cables.

**IEC-183** - Guide to the Selection of High Voltage Cables.

**IEC-189 (P1 to P7)** - Low frequency cables and wires with PVC insulation and PVC sheath.

**IEC-227 (P1 to P7)** - Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V.

**IEC-228** - Conductors of insulated cables

**IEC-230** - Impulse tests on cables and their accessories.

**IEC-287 (P1 to P3)** - Calculation of the continuous current rating of cables (100% load factor).

**IEC-304** - Standard colours for insulation for low-frequency cables and wires.

**IEC-331** - Fire resisting characteristics of Electric cables.

**IEC-332 (P1 to P3)** - Tests on electric cables under fire conditions.

**IEC-502** - Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV

**IEC-754 (P1 and P2)** - Tests on gases evolved during combustion of electric cables.

**Galvanizing**

**ASTM-A-123** - Specification for zinc (Hot Galvanizing) Coatings, on products Fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.

**ASTM-A-121-77** - Zinc-coated (Galvanized) steel barbed wire

**Painting**

**ANSI-Z551** - Gray finishes for industrial apparatus and equipment

**SSPEC** - Steel structure painting council

**HORIZONTAL CENTRIFUGAL PUMPS**

**API-610** - Centrifugal pumps for general services

**BS:599** - Methods of testing pumps

**PTC-8.2** - Power Test Codes - Centrifugal pumps
CHAPTER 20 - 220KV CLASS SPECIFICATIONS FOR TRANSFORMERS

(Transformer up to 220 kV class)

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CHAPTER 20 - 220KV CLASS SPECIFICATIONS FOR TRANSFORMERS

(Transformer up to 220 kV class)

1.0 General

1.1 This specification covers design, engineering, manufacture, testing at manufacturer’s works, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2 Transportation

1.2.1 The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer’s work to site.

1.2.2 The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of transformer and based on route survey; any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the bidder.

1.2.3 The Contractor shall dispatch the transformer filled with oil or in an atmosphere of nitrogen or dry air. In the former case the contractor shall take care of the weight limitation on transport and handling facility at site. In the latter case, necessary arrangement shall be ensured by the contractor to take care of pressure drop of nitrogen or dry air during transit and storage till completion of oil filling during erection. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

1.2.4 Transformer shall also be fitted with at least one Electronic impact recorder (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory before dispatch and must continue till the unit is installed on its foundation. The data of electronic impact recorder(s) shall be down loaded at site and a soft copy of it shall be handed over to Engineer-in-charge. Further, within three weeks the contractor shall communicate the interpretation of the data. In the unlikely event of impact recorder output not available at site, the equipment shall be thoroughly internally inspected by the manufacturer’s representative before erection at site to ensure healthiness of the equipment. Contractor shall mount Vehicle tracking system (GPRS/ GPS/ GSM based) to track the exact position of the vehicle on which the equipment is being loaded for transportation in order to ensure traceability and safety during transportation.

2.0 Performance

2.1 The transformers shall be used for bi-directional flow of rated power.
2.2 Transformers shall be capable of operating under natural cooled condition up to the full/Specified load. Transformers shall be fitted with coolers, capable of dissipating total losses at continuous maximum rating.

2.3 The transformers shall be capable of being operated, without danger, on any tapping at the rated MVA with voltage variation of ±10% corresponding to the voltage of the tapping.

2.4 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over voltage condition it does not exceed 1.9 Tesla at any tap position.

2.5 DGA of oil shall be periodically monitored by the Employer and the interpretation of DGA results will be as per IEC - 60599.

2.6 Radio Interference and Noise Level

2.6.1 The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.

2.6.2 The noise level of transformer, when energized at normal voltage and frequency with cooler equipments in operation shall not exceed, when measured under standard conditions, the values specified at relevant clause.

2.7 The transformers shall be capable of being loaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

2.8 The transformer and all its accessories including CTs etc. shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 3 secs. The short circuit level of the HV & LV System to which the subject transformers will be connected is 40 kA for 1 sec (sym, rms, 3 phase fault) on 220kV, 31.5 kA (sym, rms,3 phase fault on 132 kV) & 25kA (sym rms 3 phase fault on 33kV).

2.9 Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.

2.10 Transformers shall withstand, without injurious heating, combined voltage and frequency fluctuations which produce the following over fluxing conditions:

- 110% for continuous operation
- 125% for 1 - minute
- 140% for 5 – seconds

2.11 Dynamic Short Circuit Test requirement

i) For 220 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 220 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case bidder has not successfully tested
220 kV or above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 220 kV class transformers shall be carried out based on design of short circuit tested 220 kV or above voltage class transformer.

ii) For 132 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 132 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case bidder has not successfully tested 132 kV or above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 132 kV class transformers shall be carried out based on design of short circuit tested 132 kV or above voltage class transformer.

2.12 Design review

The transformers shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc so that the transformer provide long life with least maintenance.

Design reviews shall be conducted by Owner or an appointed Consultant at different stages of the procurement process for transformer, however the entire responsibility of design shall be with the manufacturer.

Owner may visit to the manufacturers works to inspect design, manufacturing and test facilities.

The design review will commence after placement of award with successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under scope of this specification.

The design review shall be conducted generally following the “Guidelines for conducting design reviews for transformers 100 MVA and 123kV and above” prepared by Cigre SC 12 Working Group 12.22.

The manufacturer shall provide all necessary information and calculations during design review to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

The manufacturer will be required to demonstrate the use of adequate safety margin for thermal, mechanical, dielectric and vibration etc. design to take into the account the uncertainties of his design and manufacturing processes.

The scope of such a design review shall at least include the following:

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<thead>
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<tbody>
<tr>
<td>1.</td>
<td>Core and magnetic design</td>
</tr>
<tr>
<td>2.</td>
<td>Winding and tapping design</td>
</tr>
<tr>
<td>3.</td>
<td>Short-circuit withstand capability</td>
</tr>
</tbody>
</table>
4. Thermal design including review of localised potentially hot area.
5. Cooling design
6. Overload capability
7. Eddy current losses
8. Seismic design, as applicable
9. Insulation co-ordination
10. Tank and accessories
10.1 Bushings and barrier design
10.2 Tap changers
10.3 Protective devices
10.4 Radiators
10.5 Oil and oil preservation system
11. Corrosion protection
12. Electrical and physical Interfaces with substation
13. Earthing
14. Processing and assembly
15. Testing capabilities
16. Inspection and test plan
17. Transport and storage
18. Sensitivity of design to specified parameters
19. Acoustic Noise
20. Spares, inter-changeability and standardization
21. Maintainability

### 3.0 Construction Details

The features and construction details of each power transformer shall be in accordance with the requirement stated hereunder.

#### 3.1 Tank and Tank Accessories

**3.1.1 Tank**

3.1.1.1 Tank shall preferably be of welded construction and fabricated from tested quality low carbon steel of adequate thickness.

3.1.1.2 All seams and those joints not required to be opened at site shall be factory welded, and wherever possible they shall be double welded. After completion of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1.

3.1.1.3 Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

3.1.1.4 The transformer shall have conventional type tank. In case the joint is welded it shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise of the joint.

3.1.1.5 Each tank shall be provided with:
(a) Lifting lugs suitable for lifting the equipment complete with oil.

(b) A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety for at least half of the total mass of the transformer filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.

(c) Suitable haulage holes shall be provided.

3.1.1.6 The tank shall be designed in such a way that it can be mounted on the rollers.

3.1.1.7 The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.

3.1.1.8 Paint system and procedures

The painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given below. The paint should not fade during drying process. The paint should be able to withstand temperature up to 120 deg. C . The detailed painting procedure shall also be submitted along with the bid which shall be finalized before award of the contract.

<table>
<thead>
<tr>
<th>Surface preparation</th>
<th>Primer coat</th>
<th>Intermedi ate undercoat</th>
<th>Finish coat</th>
<th>Total dry film thickness (DFT)</th>
<th>Colour shade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main tank, pipes, conservator tank, oil storage tank etc. (external surfaces)</td>
<td>Shot Blast cleaning Sa 2 ½*</td>
<td>Epoxy base Zinc primer (30-40μm)</td>
<td>Epoxy high build Micaceou s iron oxide (HB MIO) (75μm)</td>
<td>Aliphatic polyurethane (PU) (Minimum 50μm)</td>
<td>Minimum 155μm</td>
</tr>
<tr>
<td>Main tank, pipes (above 80 NB), conservator tank, oil storage tank etc. (Internal surfaces)</td>
<td>Shot Blast cleaning Sa 2 ½*</td>
<td>Hot oil resistant, non-corrosive varnish or paint or epoxy</td>
<td>--</td>
<td>--</td>
<td>Minimum 30μm</td>
</tr>
<tr>
<td>Radiator (external surfaces)**</td>
<td>Chemical / Shot Blast cleaning Sa 2 ½*</td>
<td>Epoxy base Zinc primer (30-40μm)</td>
<td>Epoxy base Zinc primer (30-40μm)</td>
<td>PU paint (Minimum 50μm)</td>
<td>Minimum 100μm</td>
</tr>
<tr>
<td>Radiator and pipes up to 80 NB (Internal surfaces)</td>
<td>Chemical cleaning, if required</td>
<td>Hot oil proof, low viscosity varnish</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Control cabinet / marshalling box/RTCC</td>
<td>Seven tank process as per IEC</td>
<td>Zinc chromate primer (two coats)</td>
<td>--</td>
<td>EPOXY paint with PU top coat</td>
<td>Minimum 80μm</td>
</tr>
</tbody>
</table>

**Note:**
* Indicates Sa 2½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.
** Radiator hot dip galvanized may also acceptable.

3.1.2 **Tank Cover**

3.1.2.1 The tank cover shall be designed to prevent retention of rain water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

3.1.2.2 At least one adequately sized inspection openings shall be provided in the transformers for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

3.1.2.3 The tank covers shall be fitted with pockets at the position of maximum oil temperature at maximum continuous rating for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

3.1.2.4 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

3.1.2.5 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression. All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.

3.1.2.6 **Tank hotspot**

The maximum temperature on any metal part shall not exceed 130 deg. Celsius.

3.1.2.7 **Currents flowing in tank cover and bushing turrets**

To allow for the effect of possible induced and capacitive surge current, good electrical connection shall be maintained between the tank and turrets.

3.1.2.8 **The transformer shall be provided with pipe flange of suitable diameter with bolted blanking plate, gasket and shall be fitted at the highest point of the transformer tank for maintaining vacuum in the tank.**
3.1.3 **Axles and Wheels**

3.1.3.1 The transformer shall be mounted on rollers, as per manufacturer's standard practice.

3.1.3.2 The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer.

3.1.3.3 The rail track gauge shall be 1676 mm.

3.1.4 **Foundation and Anti Earthquake Clamping Device**

To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

3.1.5 **Conservator & Oil Preservation System**

Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture, and shall be fitted with magnetic oil level gauge with low oil level potential free contacts.

3.1.5.2 OLTC shall have conventional type conservator with prismatic oil level gauge.

3.1.5.3 **Conservator tank and pipe work**

3.1.5.3.1 Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100degC. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil. The Calculation shall be submitted during design review.

3.1.5.3.2 The conservator shall be fitted with integral lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator wherever applicable.

3.1.5.3.3 Conservator shall be positioned so as not to obstruct any electrical connection to transformer. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

3.1.5.3.4 Pipe work connections shall be of adequate size for their duty and as short and direct as possible. Only radiused elbows shall be used.

3.1.5.3.5 The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay.

3.1.5.3.6 This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degree.
3.1.5.4 Oil Preservation Equipment

The requirements of air cell type oil sealing system are given below.

3.1.5.4.1 Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth.

3.1.5.4.2 The temperature of oil is likely to rise upto 100 deg C during operation. As such air cell used shall be suitable for operating continuously at 100 deg C.

3.1.5.4.3 Air cell of conservator shall be able to withstand the vacuum during installation/maintenance periods. Otherwise provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, the recommended replacement intervals and the supplier.

3.1.5.4.4 The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator.

3.1.5.5 Dehydrating Filter Breather

Conservator shall be fitted with a dehydrating filter breather. It shall be so designed that:

a) Passage of air is through silicagel.
b) Silicagel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in colour of the tinted crystals can be easily observed from a distance.
d) Breather is mounted not more than 1200 mm above rail top level.
e) To minimise the ingress of moisture two breathers (of identical size) shall be connected in series for main tank conservator and two breathers (of identical size) shall be connected in series for OLTC tank conservator.

3.1.5.6 Pressure Relief Device

Adequate number of pressure relief devices shall be provided at suitable locations. These shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall operate at a static pressure less than the hydraulic test pressure of the transformer tank. It shall be mounted directly on the tank. One set of electrically insulated contacts shall be provided for alarm/tripping. Discharge of pressure relief device shall be properly taken through pipes and directed away from the transformer/other equipment and this shall be prevented from spraying on the tank. Following routine tests shall be conducted on PRD

a. Air pressure test 
b. Liquid pressure test 
c. Leakage test 
d. Contact test 
e. Dielectric test.
3.1.5.7 **Buchholz Relay**

A double float/reed type Buchholz relay shall be provided. Any gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper/stainless steel tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling with the transformer in service. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. Buchholz relay shall be type tested as per international standards. Buchholz relay and its terminal box shall conform to IP 55 degree of protection.

3.1.5.8 **Temperature Indicators**

3.1.5.8.1 **Oil Temperature Indicator (OTI)**

All transformers shall be provided with a 150 mm (approx.) dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device shall be provided in the OTI. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read atleast every 2 deg C. Accuracy of OTI shall be ± 3.0 deg C or better. The setting of alarm and tripping contacts shall be adjustable at site.

In addition to the above, the following equipment shall be provided for remote indication of oil temperature:

a) **Signal transmitter**

Signal transmitter shall have additional facility to transmit signal for recording oil temperature at Employer's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for OTI system which will be used for both remote OTI and DAS. Necessary equipment for sending the signal to remote OTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

b) **Remote oil temperature indicator**

It shall be suitable for flush mounting on Employer's/RTCC panel. This shall not be repeater dial of local OTI and will operate by signal transmitter.

Any special cable required for shielding purpose, for connection between cooler control cabinet and remote OTI control circuit, shall be in the scope of Contractor. Only one ROTI with a four point selector switch shall be provided.
3.1.5.8.2 **Winding Temperature Indicator (WTI)**

A device for measuring the hot spot temperature of each winding shall be provided (HV and LV). It shall comprise the following:

i) Temperature sensing element.

ii) Image coil.

iii) Auxiliary CTs, if required to match the image coil, shall be furnished and mounted in the cooler control cabinet.

iv) 150 mm (approx) dia local indicating instrument with maximum reading pointer and two adjustable electrically independent, ungrounded contacts; besides that required for control of cooling equipment if any, one for high winding temperature alarm and one for trip. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C.

v) Calibration device.

vi) Accuracy of WTI shall be ± 3.0 deg C or better. The setting of alarm and tripping contacts shall be adjustable at site and typical values are as given below which will be reviewed during detailed engineering based on manufacturer’s recommendation.

- Alarm – 110degC
- Trip - 120degC

vii) In addition to the above, the following equipment shall be provided for remote indication of winding temperature for each of the winding:

a) Signal transmitter for each winding

Signal transmitter shall have additional facility to transmit signal for recording winding temperature at Employer's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for WTI system which will be used for both remote WTI and DAS. Necessary equipment for sending the signal to remote WTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

b) Remote winding temperature indicator

It shall be suitable for flush mounting on Employer's panel. This shall not be repeater dial of local WTI and will operate by signal transmitter.

Any special cable required for shielding purpose, for connection between cooler control cabinet and remote WTI control circuit, shall be in the scope of Contractor. Only one RWTI with a selector switch shall be provided for all the windings (HV and LV).
3.1.9 **Earthing Terminals**

3.1.9.1 Two (2) earthing pads (each complete with two (2) nos. holes, M 10 bolts, plain and spring washers) suitable for connection to 75 x 6 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

3.1.9.2 Two earthing terminals suitable for connection to 75 x 6 mm galvanised steel flat shall also be provided on cooler, marshalling box and any other equipment mounted separately.

3.2 **Core**

3.2.1 The core shall be constructed from prime quality, non-ageing, cold rolled, super grain oriented, silicon steel laminations.

3.2.2 The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating. The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under most extreme operating condition. Adequate temperature margin shall be provided to maintain longer life expectancy for this material.

3.2.3 The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 KV (rms) for 1 minute.

3.2.4 Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

3.2.5 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

3.2.6 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

3.2.7 The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

3.2.8 Adequate lifting lugs will be provided to enable the core and windings to be lifted.

3.2.9 The core shall be earthed to the core clamping structure at one point only, through a removable external link suitably located and protected to facilitate testing after installation of the transformer.

In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

A drawing furnishing the details of the internal earthing design shall be included in the manual.
3.3 Windings

3.3.1 The Contractor shall ensure that windings of all transformers are made in dust proof and conditioned atmosphere.

3.3.2 The conductors shall be of electrolytic grade copper free from scales and burrs.

3.3.3 The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inactive in transformer oil during service.

3.3.4 Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

3.3.5 The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

3.3.6 The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

3.4 Unused inhibited Insulating Oil

3.4.1 The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified below, while tested at supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned below, prior to dispatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer and only thereafter be brought up to the specified parameter by circulation within the transformer.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Property</th>
<th>Test Method</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.</td>
<td>Function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a.</td>
<td>Viscosity at 100degC</td>
<td>ISO 3104 or ASTM D445 or ASTM D7042</td>
<td>(Max.) 3 mm²/s</td>
</tr>
<tr>
<td>1b.</td>
<td>Viscosity at 40degC</td>
<td>ISO 3104 or ASTM D445 or ASTM D7042</td>
<td>(Max.) 12 mm²/s</td>
</tr>
<tr>
<td>1c.</td>
<td>Viscosity at -30degC</td>
<td>ISO 3104 or ASTM D445 or ASTM D7042</td>
<td>(Max.) 1800 mm²/s</td>
</tr>
<tr>
<td>2.</td>
<td>Appearance</td>
<td>A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature</td>
<td>The oil shall be clear and bright, transparent and free from suspended matter or sediment</td>
</tr>
<tr>
<td>3.</td>
<td>Pour point</td>
<td>ISO 3016 or ASTM D97</td>
<td>(Max.) - 40degC</td>
</tr>
<tr>
<td>4.</td>
<td>Water content</td>
<td>IEC 60814 or ASTM D1533</td>
<td>(Max.) 30 mg/kg</td>
</tr>
<tr>
<td></td>
<td>a) for bulk supply</td>
<td></td>
<td>40 mg/kg</td>
</tr>
<tr>
<td></td>
<td>b) for delivery in drums</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Electric strength</td>
<td>IEC 60156 or ASTM D1298</td>
<td>(Min.) 50 kV(new unfiltered oil) / 70 kV (after treatment)</td>
</tr>
<tr>
<td></td>
<td>(breakdown voltage)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Density at 20 deg C</td>
<td>ISO 3675 or ISO 12185</td>
<td>0.820 - 0.895 g/ml</td>
</tr>
<tr>
<td>No.</td>
<td>Requirement</td>
<td>Standard/Reference</td>
<td>Max. or Min. Value</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>7.</td>
<td>Dielectric dissipation factor (tan delta) at 90 deg C</td>
<td>IEC 60247 or IEC 61620 Or ASTM D924</td>
<td>(Max) 0.0025</td>
</tr>
<tr>
<td>8.</td>
<td>Resistivity at 90 deg C</td>
<td>IEC 60247</td>
<td>150 X 10^12 Ohm - cm, (Min.) for records only.</td>
</tr>
<tr>
<td>9.</td>
<td>Negative impulse testing KVP @ 25 deg C</td>
<td>ASTM D-3300</td>
<td>145 (Min.)</td>
</tr>
<tr>
<td>10.</td>
<td>Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds.)</td>
<td>IEC 60590 or ASTM D 2140</td>
<td>Max. Aromatic : 4 to 12 % Paraffins : &lt;50% &amp; balance shall be Naphthenic compounds.</td>
</tr>
</tbody>
</table>

**B1. Refining / Stability**

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
<th>Standard/Reference</th>
<th>Max. or Min. Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acidity</td>
<td>IEC 62021-1 or ASTM D974</td>
<td>(Max) 0.01 mg KOH/g</td>
</tr>
<tr>
<td>2.</td>
<td>Interfacial tension at 27degC</td>
<td>ISO 6295 or ASTM D971</td>
<td>(Min) 0.04 N/m</td>
</tr>
<tr>
<td>3.</td>
<td>Total sulfur content</td>
<td>BS 2000 part 373 or ISO 14596</td>
<td>0.15 % (Max.)</td>
</tr>
<tr>
<td>4.</td>
<td>Corrosive sulphur</td>
<td>IEC 62535</td>
<td>Non-Corrosive on copper and paper ASTM D1275B Non-Corrosive</td>
</tr>
<tr>
<td>5.</td>
<td>Presence of oxidation inhibitor</td>
<td>IEC 60666 or ASTM D2668 or D4768</td>
<td>0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives. Supplier should declare presence of additives, if any.</td>
</tr>
<tr>
<td>6.</td>
<td>2-Furfural content</td>
<td>IEC 61198 or ASTM D5837</td>
<td>25 Microgram/litre (Max.)</td>
</tr>
</tbody>
</table>

**C1. Performance**

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
<th>Standard/Reference</th>
<th>Max. or Min. Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Oxidation stability - Total acidity - Sludge - Dielectric dissipation factor (tan delta) at 90degC</td>
<td>IEC 61125 (method c) Test duration 500 hour IEC 60247</td>
<td>Max 0.3 mg KOH/g Max 0.05 % Max 0.05</td>
</tr>
<tr>
<td>2.</td>
<td>Gassing</td>
<td>IEC 60628A or ASTM D2300</td>
<td>No general requirement</td>
</tr>
<tr>
<td>3.</td>
<td>Oxidation stability (Rotating Bomb test )</td>
<td>IEC : 61125(Method B) / ASTM D2112 (e)</td>
<td>220 Minutes (Min.)</td>
</tr>
</tbody>
</table>

**D1. Health, safety and environment (HSE)**

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
<th>Standard/Reference</th>
<th>Max. or Min. Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Flash point</td>
<td>ISO 2719</td>
<td>(Min.) 135degC</td>
</tr>
<tr>
<td>2.</td>
<td>PCA content</td>
<td>BS 2000 Part 346</td>
<td>Max 3%</td>
</tr>
<tr>
<td>3.</td>
<td>PCB content</td>
<td>IEC 61619 or ASTM D4059</td>
<td>Not detectable (Less than 2 mg/kg)</td>
</tr>
</tbody>
</table>
3.4.2 i) Prior to filling in main tank at site and shall be tested for

1. Break Down voltage (BDV) : 70kV (min.)
2. Moisture content : 5 ppm (max.)
3. Tan-delta at 90 °C : 0.0025 (max)
4. Interfacial tension : More than 0.004 N/m

ii) Prior to energisation at site oil shall be tested for following properties & acceptance norms as per below generally in line with IEC 60422:

1. Break Down voltage (BDV) : 70 kV (min.)
2. Moisture content : 10 ppm (max.)
3. Tan-delta at 90 °C : 0.01 (max.)
4. Resistivity at 90 °C : 6 X 10 ^12 ohm-cm (min.)
5. Interfacial tension : 0.035 N/m (min.)
6. *Oxidation Stability (Test method as per IEC 61125 method C, Test duration: 500 hour for inhibited oil)
   a) Acidity : 0.3 (mg KOH /g) (max.)
   b) Sludge : 0.05 % (max.)
   c) Tan delta at 90 °C : 0.05 (max.)
7. * Total PCB content : Not detectable (2 mg/kg total)

* For Sr. No. 6 & 7 separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of Consultant.

3.4.3 At manufacturer's works the quality of oil used for first filling, testing and impregnation of active parts shall meet at least parameters as mentioned in serial no. 1 to 5 of clause 3.4.2 ii) above. The oil test results shall form part of equipment test report.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shutdown. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

3.5 Terminal Arrangements

3.5.1 Bushings

3.5.1.1 Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare Transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

3.5.1.2 Bushing for voltage of 52 kV and above shall be RIP bushing with composite polymer insulator. 36 kV and below voltage class bushing shall be solid porcelain or oil communicating type.

3.5.1.3 RIP type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.
3.5.1.4 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

3.5.1.5 Bushings of identical rating shall be interchangeable.

3.5.1.6 Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing. End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type &Routine test)

RIP Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

3.5.1.7 Clamps and fittings shall be of hot dip galvanised steel.
3.5.1.8 Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

3.5.1.9 No arcing horns shall be provided on the bushings.

3.5.1.10 Suitable insulating cap (preferably of porcelain) shall be provided on the terminal of Bushing of tertiary winding to avoid accidental external short circuit.

3.5.1.11 Installation procedures for the various voltage class bushings shall be clearly brought out in the Instruction manual.

3.5.1.12 Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP) at Transformer manufacturing works as routine test before despatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

3.5.1.13 If the bushing Tan delta goes beyond 0.005 or increase is more than 0.001 within the warrantee period w.r.t. pre-commissioning values, the contractor shall arrange to replace the defective bushing by new one. No temperature correction factor shall be applicable for tan delta.

3.5.2 Terminal Marking

The terminal marking and their physical position shall be as per IEC: 60076.

3.5.3 Neutral Earthing Arrangement

3.5.3.1 For 3-Phase Unit

The neutral terminals of transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 6 mm galvanised steel flats connected to Employer's grounding mat.

3.5.3.2 For 1-Phase Unit

The neutral of the transformer shall be brought out through bushing. The contractor shall connect the neutrals of 1-phase transformers by overhead connection using an overhead common brass/tinned copper/Aluminum pipe /ACSR conductor grounding bus, supported from the tank and fire walls by using porcelain insulators. All material like Bus post insulator, Aluminium tube, conductor, clamps & connectors, earthing materials, support structure, hardware etc required for neutral formation and connection with neutral CT and earthing of neutral shall be provided by contractor. The neutral formation shall be such that neutral winding of single-phase spare transformer can be disconnected or connected to either of the three phase banks.

3.5.4 Delta Formation (applicable for 1-Phase Transformer)

The tertiary/LV winding terminals of the transformer shall be brought out through bushing. The contractor shall connect Tertiary/LV of 1-phase transformers in DELTA configuration by overhead connection to operate in 3-Phase Bank. The Delta shall be formed by approximate size of 3" IPS Al tube, which shall be insulated with heat shrinkage insulating sleeve or cable of suitable voltage class and adequate thickness and shall be supported by structure mounted bus post insulators at suitable intervals.
The minimum phase to phase horizontal spacing for delta formation shall be 1.5 meter. All associated materials like bus post insulators, Aluminium tube, clamps & connectors, support structures; hardware etc. required for tertiary delta formation shall be provided by the contractor.

### 3.5.5 Spare Unit connection arrangement (as applicable for 1-Phase Transformer)

The contractor shall make connection arrangement as well as control scheme of OLTC and Cooler in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting it from its location. For this purpose, HV, IV, Tertiary and Neutral Connections of spare unit are to be extended up to the other unit by forming auxiliary buses with tertiary connection insulated with heat shrinkage insulating sleeve of suitable voltage class and adequate thickness and shall be supported by structure mounted bus post insulators at suitable intervals to enable spare unit connection through flexible/rigid conductor and suitable connector in place of existing unit to be replaced. For connection of spare unit in place of other units, HV, LV, Tertiary delta and neutral connection change over will be achieved by the help of manual connection changeover. Provision of manual changeover should be such that changeover can be achieved in very less time. However, the detail configuration and actual sizes of various items shall be finalized during detailed engineering and shall be subject to Employer’s approval. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement shall be provided by the contractor.

### 3.6 Cooling Equipment and its Control

#### 3.6.1 Cooling Equipment

- **3.6.1.1** The cooler shall be designed using sufficient number of tank mounted radiators. Design of cooling system shall satisfy the performance requirements.

- **3.6.1.2** Tank mounted radiators shall have its cooling fans, shut off valves at the top and bottom of suitable size, lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

- **3.6.1.3** Required number of standby fans of approximately 20% capacity shall also be provided with radiators.

- **3.6.1.4** Cooling fans shall be directly mounted on radiator. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

- **3.6.1.5** Cooling fans motors shall be suitable for operation from 400 volts, three phase 50 Hz power supply and shall conform to IEC. Each cooling fan motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55.

- **3.6.1.6** The cooler and its accessories shall preferably be hot dip galvanised or corrosion resistant paint (as per clause 3.1.1.8) should be applied to it.

- **3.6.1.7** Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section can be drained independently.
3.6.2 Cooling Equipment Control (ONAN/ONAF COOLING)

3.6.2.1 Automatic operation control of fans shall be provided (with temperature change) from contacts of winding temperature indicator. The Contractor shall recommend the setting of WTI for automatic changeover of cooler control from ONAN to ONAF. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

3.6.2.2 Suitable manual control facility for cooler fans shall be provided.

3.6.2.3 Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans manually.

3.6.2.4 Indicating Devices

   Following lamp indications shall be provided in cooler control cabinet:
   a) Control Supply failure.
   b) Cooling fan failure.
   c) Common thermal overload trip

   One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet for further wiring to Common Marshalling Box (CMB).

3.6.2.5 Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided at common marshalling box. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the CMB. Power supply to individual phase unit shall be extended from the CMB. Power supply to spare unit shall be extended from nearest CMB only. Suitably rated power contactors, separate MCBs/MCCBs shall be provided in the Common Marshalling Box for each circuit.

3.6.2.6 Control and power supplies are to be given for Cooler circuits after suitable selection at Common Marshalling Box. Necessary isolating switches and protective devices shall be provided at suitable points as per Purchaser’s approved scheme. The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder as mentioned above. In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

3.6.2.7 For each circuit, suitably rated MCBs/MCCBs as required for further distribution of auxiliary power supply to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor Box etc. (as applicable), shall be provided by contractor, in individual marshalling boxes /cooler control boxes.

3.6.3 Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from common marshalling box to individual MB/Cooler Control Cubicle (including spare unit) & further distribution from IMB/CCC to all accessories is in the scope of the contractor. Further any special cable (if required) from CMB to Owner’s Control Panels/RTCC panels are also in the scope of the contractor.
3.6.4 The cooler control cabinet / Individual Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired up to the terminal board in the cooler control cabinet/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use. All the necessary terminations for remote connection to Purchaser's panel shall be wired up to the Common Marshalling box.

3.6.5 Connection arrangement for spare unit shall be in such a way that a spare unit of transformer can be connected in place of a faulty unit without physically shifting and all the control, protection, indication signals of a spare unit shall also be brought in common marshalling box of all the banks. Necessary arrangement in schematic of Common marshalling box is required to facilitate change-over of all the signals of faulty units to spare unit of Transformer, to ensure flow of control, protection and indication signals between Purchaser’s Control panels / Digital RTCC Panel / SCADA and individual units under operation (i.e. any designated unit for bank or spare unit, if it replace any designated unit). To facilitate change-over of spare unit signals with faulty unit in CMB, male-female plug-in connector or better arrangement shall be provided to reduce the outage time.

3.6.6 Valves

3.6.6.1 All valves shall be of gun metal or of cast steel/cast iron. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

3.6.6.2 Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

3.6.6.3 Each valve shall be provided with the indicator to show clearly the position of the valve.

3.6.6.4 All valves flanges shall have machined faces.

3.6.6.5 All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.

3.6.6.6 The oil sampling point for main tank shall have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

3.6.6.7 A valve or other suitable means shall be provided to fix (in future) on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location & size of the same shall be finalised during detail engineering stage.

3.6.6.8 After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to international standards. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to International Standards followed by two coats of fully glossy finishing paint.

3.6.6.9 All hardware used shall be cadmium plated/electro galvanised steel.
3.6.6.10 For estimation purpose of spares one set of valves would mean one valve of each type used in Transformer.

3.7 Tap Changing Equipment

Each transformer shall be provided with On Load Tap changing equipment.

3.7.1 On Load Tap Changing Gear (OLTC)

OLTC shall be motor operated for local as well as remote operation. An external handle shall be provided for local manual operation. This handle shall be suitable for operation by a man standing at ground level.

3.7.1.1 Each three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load and without producing phase displacement.

3.7.1.2 The requirements of on load tap changing equipment are given here below:

a) The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer.

b) The contacts shall be accessible for inspection without lowering oil level in the main tank and the contact tips shall be replaceable.

c) The Bidder shall indicate the safeguards in order to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer. Necessary tools and tackles shall be furnished for maintenance of OLTC gear.

d) The diverter switch or arcing switch oil chamber shall have oil filling and drain plug, oil sampling valve, relief vent and level glass. It shall also be fitted with a oil surge relay the outlet of which shall be connected to a separate conservator tank.

e) The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of ancillary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment.

f) Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

g) Local OLTC control cabinet shall be mounted on the tank in accessible position. It should be adequately ventilated and provided with anti-condensation metal clad heaters. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
h) Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command. Subsequent tap changes shall be initiated only by a new or repeat command.

i) On load tap changer shall be equipped with a time delayed INCOMPLETE STEP alarm consisting of a normally open contact which closes, if the tap changer fails to make a complete tap change. The alarm shall not operate for momentary loss of auxiliary power.

j) The selsyn units or approved equivalents shall be installed in the local OLTC control cabinet to provide tap position indication for the transformer. The Bidder shall also provide a set of instruments for tap position indication in the control room. Complete mounting details shall be included in the approved diagram.

k) Transformer on load tap shall be equipped with a fixed resistor network capable of providing discrete voltage steps for input to the supervisory system.

l) Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the circuit of the operating motor. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition.

m) Limit switches may be connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated.

n) Thermal device or other means shall be provided to protect the motor and control circuit. All relays, switches, fuses etc. shall be mounted in the local OLTC control cabinet and shall be clearly marked for the purpose of identification.

o) A permanently legible lubrication chart if required, shall be fitted within the local OLTC control cabinet.

p) Any 'DROP DOWN' tanks associated with the tap changing apparatus shall be fitted with guide rod to control the movements during lifting or lowering.

q) A counter of at least five digits shall be fitted to the tap changing equipment to indicate the number of operations completed and shall have no provision for resetting.

r) All relays and operating devices shall operate correctly at any voltage between the limits specified.

s) It shall not be possible to operate the electric drive when the manual operating gear is in use.

t) It shall not be possible for any two controls to be in operation at the same time.

u) The equipment shall be suitable for supervisory control and indication with make before break multi-way switch, having one potential free contact for
each tap position. This switch shall be provided in addition to any other switch/switches which may be required for remote tap position indication.

v) Operation from the local or remote control switch shall cause one tap movement only until the control switch is returned to the off position between successive operations.

w) All electrical control switches and the local operating gear shall be clearly labelled in a suitable manner to indicate the direction of tap changing.

x) Transfer of source in the event of failure of one AC supply shall not affect the tap changer.

3.7.1.3 OLTC Control of Three Phase Transformers

Each three phase transformer shall be suitable for local and remote control. The control feature shall provide the following:

3.7.1.3.1 Local Electrical Control

(a) 'Local-remote' selector switch mounted in the local OLTC control cabinet shall switch control of all load tap changers as followings:

i) When the selector switch is in 'local' position, it shall be possible to operate the 'raise-lower' control switches specified in clause 3.9.3.1(b) below. Remote control of the raise-lower functions shall be prevented.

ii) When the selector switch is in 'remote' position the local OLTC control cabinet mounted 'raise-lower' switch specified in clause 3.9.3.1(b) below shall be inoperative. Remote control of the raise/lower function shall be possible from the remote control panel. The 'local-remote' selector switch shall have at least two spare contacts per position which are closed in that position but open in the other position.

(b) A 'raise-lower' control switch/push button shall be provided in the local OLTC control cabinet. This switch shall be operative only when 'local remote' selector switch is in 'local' position.

(c) An OFF-ON tap changer control switch shall be provided in the local OLTC control cabinet of the transformer. The tap changer shall be in-operative in the OFF position. Also the OFF-ON switch shall have at least one spare contact per position which is closed in that position but open in the other position.

3.7.1.3.2 Manual Control

The cranking device for manual operation of the OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

a) Mechanical tap position indicator which shall be clearly visible from near the transformer.

b) A mechanical operation counter.
c) Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.

d) The manual control considered as back up to the motor operated load tap changer control shall be interlocked with the motor to block motor start-up during manual operation. The manual operating mechanism shall be labelled to show the direction of operation for raising the HV terminal voltage and vice-versa.

3.7.1.3.3 Remote Electrical Group Control

The OLTC control scheme offered shall have provision of remote electrical group control during the parallel operation of transformer. This is in addition to independent control of OLTC:

i) A four position selector switch having Master, Follower, Independent and Off position shall be provided in the remote OLTC control panel for each transformer. This shall be wired to enable operator to select operation of OLTC in either Master, Follower or Independent mode.

ii) Out of step relays with timer contacts shall also be provided to give alarm and indication in case tap position in all the transformers under group control are not in same position.

iii) Master Position

If the selector switch is in Master position, it shall be possible to control the OLTC units in the follower mode by operating the controls of the master unit. Independent operation of the units under Follower mode shall have to be prevented. However the units under independent mode will be controlled independently.

iv) Follower Position

If the selector switch is in Follower mode, control of OLTC shall be possible only from panel of the Master unit.

v) Independent Position

In this position of Selector Switch, Control of OLTC of individual unit shall only be possible.

3.7.1.5 The control circuits shall comply with following conditions:

3.7.1.5.1 An interlock to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

3.7.1.5.2 Reinforcement of the initiating impulse for a tap change, ensuring a positive completion once initiated to the next (higher or lower) tap.

3.7.1.5.3 "Step-by-Step" operation ensuring only one tap change from each tap changing impulse and a lock-out of the mechanism if the control switch (or push button) remains in the "operate" position.
3.7.1.5.4 An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

3.7.1.5.5 An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

3.7.1.5.6 Tap change in progress indication shall be provided by means of an indicating lamp at the Employer's control panel. Necessary contacts for this and for remote tap position indicator at Employer's control panel shall be provided by the Bidder.

3.7.1.5.7 Protective apparatus, considered essential by the Bidder according to specialities of the gear.

3.7.2 Local OLTC Control Cabinet, Cooler Control Cabinet and Remote Tap Changer Control Panel

3.7.2.1 Each three phase transformer unit shall be provided with local OLTC control cabinet, cooler control cabinet and RTCC panel.

3.7.2.2 Cabinets and Panels shall be tank mounted, provided with suitable lifting arrangement and have sloping roof.

3.7.2.3 A space heater, and cubicle lighting with ON-OFF switch shall be provided in each panel.

3.7.3 Necessary shorting of terminals shall be done at the cooler control cabinet, local OLTC cabinet and remote OLTC panel. All the CT secondary terminals in the cooler control cabinet shall have provision for short circuiting to avoid CT open circuit while it is not in use.

3.7.4 Cooler Control Cabinet

3.7.4.1 The cooler control cabinet shall have all necessary devices meant for cooler control and local temp indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet. All the necessary terminals for remote connection to Employer's panel shall be wired upto the cooler control cabinet.

3.7.4.2 The cooler control cabinet shall have two (2) sections. One section shall have the control equipment exclusively meant for cooler control. The other section shall house the temperature indicators, aux. CTs and the terminal boards meant for termination of various alarm and trip contacts as well as various bushing CT secondary. Alternatively the two sections may be provided as two separate panels depending on the standard practice of the Bidder.

3.7.4.3 The temperature indicators shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

3.7.5 Local OLTC Control Cabinet

The Local OLTC control cabinet shall house all necessary devices meant for OLTC control and indication. It shall be complete with the following:
i) A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor.

ii) Cubicle light with door switch.

iii) Space heaters to prevent condensation of moisture.

iv) Locking arrangement for hinged door of cabinet.

v) Cable terminal glands for power and control cables to the OLTC gear.

3.7.6 Remote Tap Changer Control Panel.

3.7.6.1 The Contractor shall supply a Remote Tap Changer Control (RTCC) panel suitable for remote operation of On load tap changing gear.

3.7.6.2 The RTCC panel shall house actuating switch for electrical raise/lower control, tap position indicator, signal lamps for "Tap change in progress" and "Tap changer out of step", and all other auxiliary devices for remote electrical control of the OLTC. For tap position indicator, the dual output type OLTC transducer shall be provided in the RTCC panel. One of the outputs of this transducer shall be used for local indication of tap position in RTCC panel and other output (0-10 mA or 4-20 mA) shall be used for RTUs/automation system.

3.7.6.3 The RTCC panel shall be located in Employer's control room / Air conditioned switchyard panel room.

3.8 Auxiliary Power Supply of OLTC, Cooler Control and Power Circuit

3.8.1 Two auxiliary power supplies, 400 volt, three phase four (4) wire shall be provided by the Employer at cooler control cabinet for OLTC and cooler control and power circuit.

3.8.2 All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer switch housed in the cooler control cabinet for on load tap changer control and cooler circuits.

Design features of the transfer switch shall include the following:

a) Provision for the selection of one of the feeder as normal source and other as standby.

b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.

c) Indication to be provided at cooler control cabinet for failure of normal source and for transfer to standby source and also for failure to transfer.

d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.

e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.
3.8.3 Power Supply for OLTC Circuits

a) AC feeder shall be brought to the local OLTC control cabinet by the Contractor after suitable selection at cooler control cabinet for which description is given in 3.10.2 above, for control power circuit of OLTC.

b) The Contractor shall derive AC power for OLTC control circuitry from the AC feeder as mentioned above by using appropriately rated dry type transformers. If the control circuit is operated by DC supply, then suitable main and standby converters shall be provided by the Contractor to be operated from AC power source.

3.8.4 Power Supply for Cooler Circuits

3.8.4.1 Control and power supplies are to be given for Cooler circuits after the selection as mentioned above.

3.8.4.2 The Contractor shall derive AC power for Cooler Control Circuitry by using appropriately rated dry type transformer in case of using supply voltage different from the Employer’s auxiliary supply. If the control circuit is operated by DC supply then suitable main and standby converters shall be provided by the Contractor, to be operated from AC power source.

3.8.5 Necessary isolating switches and MCBs/MCCBs shall be provided at suitable points as per Employer’s approved scheme.

4 Fittings

4.1 The following fittings shall be provided with each three phase transformer covered in this specification.

4.1.1 Conservator for main tank with oil filling hole and cap, air cell, isolating valves, drain valve, magnetic oil level gauge with low level alarm contacts and dehydrating silicagel breather.

4.1.2 Pressure relief devices with alarm/trip contacts.

4.1.3 Buchholz relay double float/reed type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm and trip contacts.

4.1.4 Air release plug.

4.1.5 Inspection openings and covers.

4.1.6 Bushing with metal parts and gaskets to suit the termination arrangement.

4.1.7 Winding temperature indicators for local and remote mounting. One remote winding temperature indicator with a four point selector switch shall be provided for the three windings for three phase unit to have selection of any of the three windings.

4.1.8 Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.
4.1.9 Protected type mercury or alcohol in glass thermometer.

4.1.10 Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve.

4.1.11 Rating and diagram plates on transformers and auxiliary apparatus.

4.1.12 Flanged bi-directional wheels/Trolley for movement

4.1.13 Cooler cabinet.

4.1.14 Off load / On load tap changing gear.

4.1.15 Cooling equipment

4.1.16 Bushing current transformers.

4.1.17 Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.

4.1.18 Terminal marking plates.

4.1.19 Valves schedule plates.

4.1.20 Oil temperature indicator for local and remote marking

4.1.21 Oil flow indicator

4.1.22 Marshalling box/Common Marshalling box

4.1.23 Suitable galvanized iron or stainless steel tray for cabling on main tank for better aesthetics.

4.1.24 Terminal clamp & connector

4.1.25 The fittings listed above are only indicative and other fittings which generally are required for satisfactory operation of the transformer are deemed to be included.

4.1.26 One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tublar with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes as used in the reactor one set ), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one ), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one) shall be supplied per Substation.

5 Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. An indication of inspection envisaged by the Employer is given under Clause 5.1. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Employer for necessary implementation.
5.1 Inspection

5.1.1 Tank and Conservator

5.1.1.1 Certification of chemical analysis and material tests of plates.

5.1.1.2 Check for flatness.

5.1.1.3 Electrical interconnection of top and bottom by braided tinned copper flexibles.

5.1.1.4 Welder’s qualification and weld procedure.

5.1.1.5 Testing of electrodes for quality of base materials and coatings.

5.1.1.6 Inspection of major weld preparation.

5.1.1.7 Crack detection of major strength weld seams by dye penetration test.

5.1.1.8 Measurement of film thickness of:

i) Oil insoluble varnish.

ii) Zinc chromate paint.

iii) Finished coat.

5.1.1.9 Check correct dimensions between wheels, demonstrate turning of wheels through 90 deg C and further dimensional check.

5.1.1.10 Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to NDT.

5.1.1.11 Leakage test of the conservator.

5.1.1.12 Certification of all test results.

5.1.2 Core

5.1.2.1 Sample testing of core materials for checking specific loss, bend properties, namedition characteristics and thickness.

5.1.2.2 Check on the quality of varnish if used on the stampings:

i) Measurement of thickness and hardness of varnish on stampings.

ii) Solvent resistance test to check that varnish does not react in hot oil.

iii) Check over all quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface.

5.1.2.3 Check on the amount of burrs.

5.1.2.4 Bow check on stampings.
5.1.2.5 Check for the overlapping of stampings. Corners of the sheet are to be part.
5.1.2.6 Visual and dimensional check during assembly stage.
5.1.2.7 Check for interlaminal insulation between core sectors before and after pressing.
5.1.2.8 Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.
5.1.2.9 High voltage test (2 kV for one minute) between core and clamps.
5.1.2.10 Certification of all test results.

5.1.3 **Insulation Material**

5.1.3.1 Sample check for physical properties of materials.

5.1.3.2 Check for dielectric strength.

5.1.3.3 Visual and dimensional checks.

5.1.3.4 Check for the reaction of hot oil on insulating materials.

5.1.3.5 Dimension stability test at high temperature for insulating material.

5.1.3.6 Tracking resistance test on insulating material.

5.1.3.7 Certification of all test results.

5.1.4 **Winding**

5.1.4.1 Sample check on winding conductor for mechanical properties and electrical conductivity.

5.1.4.2 Visual and dimensional checks on conductor for scratches, dent marks etc.

5.1.4.3 Sample check on insulating paper for pH value, bursting strength and electric strength.

5.1.4.4 Check for the reaction of hot oil on insulating paper.

5.1.4.5 Check for the bonding of the insulating paper with conductor.

5.1.4.6 Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.

5.1.4.7 Check for absence of short circuit between parallel strands.

5.1.4.8 Check for brazed joints wherever applicable.

5.1.4.9 Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready.

5.1.4.10 Conductor enamel test for checking of cracks, leakage and pin holes.
5.1.4.11 Conductor flexibility test
5.1.4.12 Heat shrink test for anameled wire.
5.1.4.13 Certification of all test results.

5.1.5 Checks Before Drying Process
5.1.5.1 Check condition of insulation on the conductor and between the windings.
5.1.5.2 Check insulation distance between high voltage connections, cables and earth and other live parts.
5.1.5.3 Check insulating distances between low voltage connections and earth and other parts.
5.1.5.4 Insulation of core shall be tested at 2 kV/minute between core to bolts and core to clamp plates.
5.1.5.5 Check for proper cleanliness and absence of dust etc.
5.1.5.6 Certification of all test results.

5.1.6 Checks During Drying Process
5.1.6.1 Measurement and recording of temperature, vacuum and drying time during vacuum treatment.
5.1.6.2 Check for completeness of drying by periodic monitoring of IR and Tan delta.
5.1.6.3 Certification of all test results.

5.1.7 Assembled Transformer
5.1.7.1 Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.
5.1.7.2 Test to check effective shielding of the tank.
5.1.7.3 Jacking test with oil on all the assembled transformers.
5.1.7.4 Dye penetration test shall be carried out after the jacking test.

5.1.8 Bought Out Items
5.1.8.1 The makes of all major bought out items shall be subject to Employer’s approval.
5.1.8.2 The Contractor shall also prepare a comprehensive inspection and testing programme for all bought out/sub-contracted items and shall submit the same to the Employer for approval. Such programme shall include the following components:

a) Buchholz Relay.
b) Axles and wheels.

c) Winding temperature indicators for local and remote mounting.

d) Oil temperature indicators.

e) Bushings.

f) Bushing current transformers.

g) Cooler cabinet.

h) ON Load / Off Load Tap change gear.

i) Oil pumps.

j) Terminal connectors.

k) Pressure relief device relay

l) Cables used for interconnecting Turret CT, equipment relays (exposed), with marshalling box.

The above list is not exhaustive and the Contractor shall also include other bought out items in his programme.

5.1.9 **Pre-Shipment Checks at Manufacturer’s Works**

5.1.9.1 Check for interchangeability of components of similar transformers for mounting dimensions.

5.1.9.2 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.1.9.3 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.1.9.4 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.1.9.5 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.1.9.6 Measure and record the dew point of dry air /Nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air / nitrogen at the time of transformer dispatch should be better than (-) 30 deg C. Also the dew point of dry air / nitrogen cylinders attached for make up during transportation should of the order of (-) 50 deg C.

5.1.9.7 Functioning of impact recorder(s) at their works before installing on the tank.

5.2 **Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing
plant in this regard when submitting the bid. Any limitations shall be clearly stated in. The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works. Procedure for some of tests is given at annexure-I.

The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated below.

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Test Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Measurement of winding resistance</td>
<td>Routine</td>
</tr>
<tr>
<td>2.</td>
<td>Voltage ratio measurement</td>
<td>Routine</td>
</tr>
<tr>
<td>3.</td>
<td>Polarity &amp; Vector group test</td>
<td>Routine</td>
</tr>
<tr>
<td>4.</td>
<td>No-load loss and current measurement</td>
<td>Routine</td>
</tr>
<tr>
<td>5.</td>
<td>Impedance voltage and load loss measurement</td>
<td>Routine</td>
</tr>
<tr>
<td>6.</td>
<td>Measurement of insulation resistance &amp; Polarization Index</td>
<td>Routine</td>
</tr>
<tr>
<td>7.</td>
<td>Measurement of insulation power factor and capacitance between winding and earth</td>
<td>Routine</td>
</tr>
<tr>
<td>8.</td>
<td>Measurement of insulation power factor and capacitance of bushings</td>
<td>Routine</td>
</tr>
<tr>
<td>9.</td>
<td>Lightning impulse test</td>
<td>Routine</td>
</tr>
<tr>
<td>10a</td>
<td>Short duration induced AC withstand Test (ACSD) with PD measurement</td>
<td>Routine</td>
</tr>
<tr>
<td>11.</td>
<td>On-load tap changer test (Ten complete cycle before LV test)</td>
<td>Routine</td>
</tr>
<tr>
<td>12.</td>
<td>Gas-in-oil analysis</td>
<td>Routine</td>
</tr>
<tr>
<td>13.</td>
<td>Core assembly dielectric and earthing continuity test</td>
<td>Routine</td>
</tr>
<tr>
<td>14.</td>
<td>Oil leakage test on transformer tank</td>
<td>Routine</td>
</tr>
<tr>
<td>15.</td>
<td>Appearance, construction and dimension check</td>
<td>Routine</td>
</tr>
<tr>
<td>16.</td>
<td>Magnetic balance test</td>
<td>Routine</td>
</tr>
<tr>
<td>17.</td>
<td>Measurement of no load current &amp; Short circuit impedance with 400 V, 50 Hz AC.</td>
<td>Routine</td>
</tr>
<tr>
<td>18.</td>
<td>High voltage with stand test on auxiliary equipment and wiring after assembly</td>
<td>Routine</td>
</tr>
<tr>
<td>19.</td>
<td>Tank vacuum test</td>
<td>Routine</td>
</tr>
<tr>
<td>20.</td>
<td>Tank pressure test</td>
<td>Routine</td>
</tr>
<tr>
<td>21.</td>
<td>Frequency response analysis (Soft copy of test report in sfra format to be submitted to site along with O &amp; M manual)</td>
<td>Routine</td>
</tr>
<tr>
<td>22.</td>
<td>Temperature rise test</td>
<td>Type</td>
</tr>
<tr>
<td>23.</td>
<td>Measurement of harmonic level in no load current</td>
<td>Type</td>
</tr>
<tr>
<td>24.</td>
<td>Measurement of acoustic noise level</td>
<td>Type</td>
</tr>
<tr>
<td>25.</td>
<td>Measurement of Zero seq. reactance</td>
<td>Type</td>
</tr>
<tr>
<td>26.</td>
<td>Measurement of power taken by fans and oil pumps</td>
<td>Type</td>
</tr>
<tr>
<td>27.</td>
<td>Dynamic Short Circuit Test</td>
<td>Type</td>
</tr>
</tbody>
</table>

All tests shall be done in line with IEC: 60076 and as per “Annexure-A”. Complete test report shall be submitted to purchaser after proper scrutiny and
signing on each page by the test engineer of the manufacturer. * Type test shall be carried out at first unit manufactured against the LOA at each manufacturing plant.

5.2.1 Measurement of capacitance and tan delta to determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% at ambient temperature.

5.2.2 Measurement of capacitance and tan delta of OIP bushings. Tan delta value shall not be more than 0.4% at ambient temperature.

5.2.3 Type Tests on fittings:

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the clause no. 9.0 of the Chapter2 – GTR. The list of fittings and the type test requirement is:

1. Bushing (Type Test as per IEC: 60137, including snap back/seismic test)

2. Buchholz relay (Type Test as per IEC and IP-55 Test on terminal box)

3. OLTC (Temperature Rise of contact, Short circuit current test, Mechanical test and Dielectric Test as per IEC: 60214 and IP-55 test on driving mechanism box).


5. Air Cell (Flexible air separator) – Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.

6. Cooler Control cabinet (IP-55 test)

7. Pressure Relief device Test

The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test above.. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.

The terminal box / boxes of PRD should conform to degree of protection as per IP-55.

8. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.


5.2.4 Pre-Shipment Checks at Manufacturer’s Works

5.2.5 Check for interchangeability of components of similar transformers for mounting dimensions.
5.2.6 Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

5.2.7 Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.2.8 Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

5.2.9 Derivation of leakage rate and ensure the adequate reserve gas capacity.

5.2.10 Measure and record the dew point of dry air/nitrogen at the time of filling and after 24 hours in the transformer tank. Dew point of dry air/nitrogen at the time of transformer despatch should be better than (-) 30 deg C. Also the dew point of dry air/nitrogen cylinders attached for make up during transportation should be of the order of (-) 50 deg C.

5.3 Inspection and Testing at Site

The Contractor/Manufacturer shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage upto commissioning stage. An indicative programme of inspection as envisaged by the Employer is given below. Pre commissioning Procedures and Formats for equipments shall be contractor's responsibility to draw up and carry out such a programme.

5.3.1 Receipt and Storage Checks

5.3.1.1 Check and record condition of each package, visible parts of the transformer etc. for any damage.

5.3.1.2 Check and record the gas pressure in the transformer tank as well as in the gas cylinder. Measure and record the dew point of dry air/nitrogen in the transformer tank.

5.3.1.3 Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

5.3.2 Installation Checks

5.3.2.1 Inspection and performance testing of accessories like tap changers etc.

5.3.2.2 (i) Check the direction of rotation of fans.

(ii) Check the bearing lubrication.

5.3.2.3 Check whole assembly for tightness, general appearance etc.

5.3.2.4 Oil leakage test

5.3.2.5 Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

5.3.2.6 Leakage test on bushing before erection.
5.3.2.7 Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

5.3.2.8 Oil filling.

5.3.2.8.1 Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70 deg C.

5.3.2.8.2 The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

5.3.2.8.3 Vacuum shall not be broken until the transformer is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete transformer. For this purpose the transformer shall first be drained to expose all insulation material.

5.3.2.8.4 The minimum safe level of oil filling (if different from the Buchholz level) to which the transformer shall be oil filled under vacuum, shall be indicated in the manual.

5.3.2.8.5 Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

5.3.3 Commissioning Checks

5.3.3.1 Check the colour of silicagel in silicagel breather.

5.3.3.2 Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

5.3.3.3 Check the bushing for conformity of connection to the lines etc,

5.3.3.4 Check for correct operation of all protection devices and alarms :

(i) Buchholz relay.

(ii) Excessive winding temperature.

(iii) Excessive oil temperature.

(iv) Low oil flow.

(v) Low oil level indication.

(vi) Fan and pump failure protection.

5.3.3.5 Check for the adequate protection on the electric circuit supplying the accessories.
5.3.3.6 Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

   (i) Control wiring.

   (ii) Main windings.

5.3.3.7 Check for cleanliness of the transformer and the surroundings.

5.3.3.8 Continuously observe the transformer operation at no load for 24 hours.

Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

5.3.3.9 Phase out and vector group test.

5.3.3.10 Ratio test on all taps.

5.3.3.11 Magnetising current test.

5.3.3.12 Capacitance and Tan delta measurement of winding and bushing.

5.3.3.13 DGA of oil just before commissioning and after 24 hours energisation at site.

5.3.3.14 Frequency response analysis (FRA) at site by the equipment to be provided by the bidder.

5.3.3.15 Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.

6.0 Technical Parameters

6.1.1 Technical Particulars / Parameters of Transformers (220/132/33 kV 1-Phase Auto Transformer)

<table>
<thead>
<tr>
<th>Cl. No.</th>
<th>Description</th>
<th>Unit</th>
<th>TECHNICAL PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Rated Capacity</td>
<td>MVA</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>HV</td>
<td>MVA</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>MVA</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>LV (Tertiary: Active Loading)</td>
<td>MVA</td>
<td>1</td>
</tr>
<tr>
<td>1.2</td>
<td>Voltage ratio (HV/IV/LV) (Line to line)</td>
<td>kV</td>
<td>(220/√3) / (132/√3) / 33</td>
</tr>
<tr>
<td>1.3</td>
<td>Single / Three Phase Design</td>
<td></td>
<td>SINGLE</td>
</tr>
<tr>
<td>1.4</td>
<td>Applicable Standard</td>
<td></td>
<td>IEC 60076</td>
</tr>
<tr>
<td>1.5</td>
<td>Frequency</td>
<td>Hz</td>
<td>50</td>
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<tr>
<td>1.6</td>
<td>Cooling</td>
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<td>ONAN/ONAF</td>
</tr>
<tr>
<td></td>
<td>ONAN/ONAF 1/ONAF2</td>
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<td></td>
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<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1.7</td>
<td>Rating at different cooling</td>
<td>%</td>
<td>60 / 100</td>
</tr>
<tr>
<td></td>
<td>60% / 80%/100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>Type of Transformer</td>
<td>Constant Ohmic impedance type (Refer Note1)</td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td>HV – IV Impedance at 75 Deg C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Max. Voltage tap</td>
<td>%</td>
<td>8.30</td>
</tr>
<tr>
<td>ii)</td>
<td>Principal tap</td>
<td>%</td>
<td>10.00</td>
</tr>
<tr>
<td>iii)</td>
<td>Min. Voltage tap</td>
<td>%</td>
<td>12.30</td>
</tr>
<tr>
<td>iv)</td>
<td>Tolerance on Impedance</td>
<td>%</td>
<td>As per IEC</td>
</tr>
<tr>
<td>1.10</td>
<td>Service</td>
<td>OUTDOOR</td>
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</tr>
<tr>
<td>1.11</td>
<td>Duty</td>
<td>CONTINUOUS</td>
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</tr>
<tr>
<td>1.12</td>
<td>Overload Capacity</td>
<td>IEC 60076-7</td>
<td></td>
</tr>
<tr>
<td>1.13</td>
<td>Temperature rise over 50deg C Ambient Temp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Top oil measured by thermometer</td>
<td>°C</td>
<td>50</td>
</tr>
<tr>
<td>ii)</td>
<td>Average winding measured by resistance method</td>
<td>°C</td>
<td>55</td>
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<tr>
<td>1.14</td>
<td>Windings</td>
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<tr>
<td>i)</td>
<td>System Fault level</td>
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<tr>
<td>HV</td>
<td>kA</td>
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<td>IV</td>
<td>kA</td>
<td>31.5</td>
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<tr>
<td>LV</td>
<td>kA</td>
<td>25</td>
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<tr>
<td>Neutral</td>
<td>kA</td>
<td>-</td>
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</tr>
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<td>ii)</td>
<td>Lightning Impulse withstand Voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HV</td>
<td>kV&lt;br&gt;&lt;i&gt;D&lt;/i&gt;</td>
<td>950</td>
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<tr>
<td>IV</td>
<td>kV&lt;br&gt;&lt;i&gt;D&lt;/i&gt;</td>
<td>550</td>
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<tr>
<td>LV</td>
<td>kV&lt;br&gt;&lt;i&gt;D&lt;/i&gt;</td>
<td>250</td>
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<tr>
<td>Neutral</td>
<td>kV&lt;br&gt;&lt;i&gt;D&lt;/i&gt;</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>iii)</td>
<td>Switching Impulse withstand Voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HV</td>
<td>kV&lt;br&gt;&lt;i&gt;D&lt;/i&gt;</td>
<td>750</td>
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<td>iv)</td>
<td>One Minute Power Frequency withstand Voltage</td>
<td></td>
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<tr>
<td>HV</td>
<td>kV&lt;br&gt;&lt;i&gt;rms&lt;/i&gt;</td>
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<td>IV</td>
<td>kV&lt;br&gt;&lt;i&gt;rms&lt;/i&gt;</td>
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<tr>
<td>LV</td>
<td>kV&lt;br&gt;&lt;i&gt;rms&lt;/i&gt;</td>
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<td>kV&lt;br&gt;&lt;i&gt;rms&lt;/i&gt;</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>v)</td>
<td>Neutral Grounding</td>
<td>Solidly grounded</td>
<td></td>
</tr>
<tr>
<td>vi)</td>
<td>Insulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HV</td>
<td>GRADED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>GRADED</td>
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<td></td>
</tr>
<tr>
<td>LV</td>
<td>UNIFORM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vii)</td>
<td>Tertiary Connection (3Ph Bank)</td>
<td>Ungrounded Delta</td>
<td></td>
</tr>
</tbody>
</table>
### 1.15 Tap Changer

<table>
<thead>
<tr>
<th>Vector Group (3–ph) (unless specified differently elsewhere)</th>
<th>YNa0Od11</th>
</tr>
</thead>
</table>

#### Tap Range & No. of steps

-5% to +15% of HV variation in the step of 1.25%, 16 steps

#### Location of Tap changer
On the 132 kV side of the series winding

#### Design
Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I

#### Tap control
Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow

### 1.17 Bushings

#### i) Rated voltage

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
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<tbody>
<tr>
<td>HV</td>
<td>kV</td>
<td>245</td>
</tr>
<tr>
<td>IV</td>
<td>kV</td>
<td>145</td>
</tr>
<tr>
<td>LV</td>
<td>kV</td>
<td>52</td>
</tr>
<tr>
<td>Neutral</td>
<td>kV</td>
<td>36</td>
</tr>
</tbody>
</table>

#### ii) Rated current (Min.)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
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<td>800</td>
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<td>A</td>
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<td>Neutral</td>
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#### iii) Lightning Impulse withstand Voltage

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<td>HV</td>
<td>kVp</td>
<td>1050</td>
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<td>kVp</td>
<td>650</td>
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<td>kVp</td>
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<td>kVp</td>
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#### iv) Switching Impulse withstand Voltage

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<td>kVp</td>
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#### v) One Minute Power Frequency withstand Voltage

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<td>kVrms</td>
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<td>LV</td>
<td>kVrms</td>
<td>105</td>
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<td>Neutral</td>
<td>kVrms</td>
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#### vi) Minimum total creepage distances

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<tr>
<td>HV</td>
<td>mm</td>
</tr>
<tr>
<td>IV</td>
<td>mm</td>
</tr>
<tr>
<td>LV</td>
<td>mm</td>
</tr>
<tr>
<td>Neutral</td>
<td>mm</td>
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#### vii) Tan delta of bushing

<table>
<thead>
<tr>
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<th>%</th>
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<tr>
<td>HV</td>
<td>&lt;0.4</td>
</tr>
<tr>
<td>IV</td>
<td>&lt;0.4</td>
</tr>
<tr>
<td>LV %</td>
<td>Neutral %</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
</tr>
<tr>
<td>v) Max Partial discharge level at ( U_m )</td>
<td></td>
</tr>
<tr>
<td>HV pC</td>
<td>10</td>
</tr>
<tr>
<td>IV pC</td>
<td>10</td>
</tr>
<tr>
<td>LV pC</td>
<td>10</td>
</tr>
<tr>
<td>1.18 Max Partial discharge level at 1.5( U_m/\sqrt{3} ) pC</td>
<td>100</td>
</tr>
<tr>
<td>1.19 Max Noise level at rated voltage and at principal tap on full load and all cooling active dB</td>
<td>75</td>
</tr>
</tbody>
</table>

**Notes:**

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. The criteria for Transformer losses shall be “Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)”.

### 6.1.2 Technical Particulars / Parameters of Transformers (220/132/33 kV 3-Phase Auto Transformer)

<table>
<thead>
<tr>
<th>Cl. No.</th>
<th>Description</th>
<th>Unit</th>
<th>TECHNICAL PARAMETERS</th>
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</thead>
<tbody>
<tr>
<td>i.1</td>
<td>Rated Capacity</td>
<td>MVA</td>
<td>160</td>
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<tr>
<td></td>
<td>HV</td>
<td>MVA</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>MVA</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>LV (Tertiary: Active Loading)</td>
<td>MVA</td>
<td>5</td>
</tr>
<tr>
<td>i.2</td>
<td>Voltage ratio (HV/IV/LV) (Line to line)</td>
<td>kV</td>
<td>(220/\sqrt{3}) / (132/\sqrt{3}) / 33</td>
</tr>
<tr>
<td>i.3</td>
<td>Single / Three Phase Design</td>
<td></td>
<td>Three</td>
</tr>
<tr>
<td>i.4</td>
<td>Applicable Standard</td>
<td></td>
<td>IEC 60076</td>
</tr>
<tr>
<td>i.5</td>
<td>Frequency</td>
<td>Hz</td>
<td>50</td>
</tr>
<tr>
<td>i.6</td>
<td>Cooling</td>
<td></td>
<td>ONAN/ONAF/(OFAF or ODAF) OR ONAN/ONAF1/ONAF2</td>
</tr>
<tr>
<td>i.7</td>
<td>Rating at different cooling</td>
<td>%</td>
<td>60% / 80% / 100%</td>
</tr>
<tr>
<td>i.8</td>
<td>Type of Transformer</td>
<td></td>
<td>Constant Ohmic impedance type (Refer Note1)</td>
</tr>
<tr>
<td>i.9</td>
<td>HV – IV Impedance at 75 Deg C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Max. Voltage tap</td>
<td>%</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>ii) Principal tap</td>
<td>%</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>iii) Min. Voltage tap</td>
<td>%</td>
<td>15.4</td>
</tr>
</tbody>
</table>
### IV. Tolerance on Impedance

| Service | OUTDOOR | As per IEC

### 1.11 Duty

| OVERLOAD |

### 1.12 Overload Capacity

| Temperature rise over 50deg C Ambient Temp |

#### i) Top oil measured by thermometer

| Top oil measured by thermometer | °C | 50 |

#### ii) Average winding measured by resistance method

| Average winding measured by resistance method | °C | 55 |

### 1.13 Temperature rise over 50deg C Ambient Temp

| Top oil measured by thermometer | °C | 50 |

### 1.14 Windings

#### i) System Fault level

| System Fault level | kA |

#### ii) Lightning Impulse withstand Voltage

| Lightning Impulse withstand Voltage | kVp |

#### iii) Switching Impulse withstand Voltage

| Switching Impulse withstand Voltage | kVp |

#### iv) One Minute Power Frequency withstand Voltage

| One Minute Power Frequency withstand Voltage | kVrms |

#### v) Neutral Grounding

| Neutral Grounding | Solidly grounded |

#### vi) Insulation

| Insulation | |

#### vii) Tertiary Connection (3Ph Bank)

| Tertiary Connection (3Ph Bank) | Ungrounded Delta |

#### viii) Tan delta of winding

| Tan delta of winding | % |

### 1.15 Vector Group (3 –ph)

| Vector Group (3 –ph) | YNa0Od11 |

| Vector Group (3 –ph) (unless specified differently elsewhere) | YNa0Od11 |

### 1.16 Tap Changer

| Tap Changer | OLTC |

#### i) Tap Range & No. of steps

| Tap Range & No. of steps | –5% to +10% of HV variation in the step of 1.25%, 12 steps |

#### ii) Location of Tap changer

| Location of Tap changer | On the 132 kV side of the series winding |

#### iii) Design

| Design | Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I |

#### iv) Tap control

| Tap control | Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow |

### 1.17 Bushings
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Rated voltage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HV</td>
<td>kV</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>kV</td>
</tr>
<tr>
<td></td>
<td>LV</td>
<td>kV</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>kV</td>
</tr>
<tr>
<td>ii)</td>
<td>Rated current (Min.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HV</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>LV</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>A</td>
</tr>
<tr>
<td>iii)</td>
<td>Lightning Impulse withstand Voltage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HV</td>
<td>kVP</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>kVP</td>
</tr>
<tr>
<td></td>
<td>LV</td>
<td>kVP</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>kVP</td>
</tr>
<tr>
<td>iv)</td>
<td>Switching Impulse withstand Voltage</td>
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</tr>
<tr>
<td></td>
<td>HV</td>
<td>kVP</td>
</tr>
<tr>
<td>v)</td>
<td>One Minute Power Frequency withstand Voltage</td>
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<td></td>
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<td>LV</td>
<td>kVrms</td>
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<tr>
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<td>Neutral</td>
<td>kVrms</td>
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<td>vi)</td>
<td>Minimum total creepage distances</td>
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<tr>
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<td></td>
<td>LV</td>
<td>mm</td>
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<td></td>
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<td>mm</td>
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<tr>
<td>vii)</td>
<td>Tan delta of bushing</td>
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<td>%</td>
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<tr>
<td></td>
<td>IV</td>
<td>%</td>
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<tr>
<td></td>
<td>LV</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>%</td>
</tr>
<tr>
<td>viii)</td>
<td>Max Partial discharge level at ( U_m )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HV</td>
<td>pC</td>
</tr>
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<td></td>
<td>IV</td>
<td>pC</td>
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<tr>
<td></td>
<td>LV</td>
<td>pC</td>
</tr>
<tr>
<td></td>
<td>1.18</td>
<td>Max Partial discharge level at ( 1.5U_m/\sqrt{3} )</td>
</tr>
<tr>
<td></td>
<td>1.19</td>
<td>Max Noise level at rated voltage and at principal tap on full load and all cooling active</td>
</tr>
</tbody>
</table>

**Notes:**

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. The criteria for Transformer losses shall be “Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)”.

6.2 Technical Particulars / Parameters of Transformers (132/33 kV, 3-Phase Power Transformer)

<table>
<thead>
<tr>
<th>Cl. No.</th>
<th>Description</th>
<th>Unit</th>
<th>TECHNICAL PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rated Capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HV</td>
<td>MVA</td>
<td>50 40 30 25</td>
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<td>LV</td>
<td>MVA</td>
<td>50 40 30 25</td>
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<td>1.2</td>
<td>Voltage ratio (HV/LV) line to line</td>
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<td>132/33</td>
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<td>Single / Three Phase Design</td>
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<td>3 (THREE)</td>
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<td>Frequency</td>
<td>Hz</td>
<td>50</td>
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<td>1.6</td>
<td>Cooling</td>
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<td>ONAN/ONAF</td>
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<td>1.7</td>
<td>Rating at different cooling</td>
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<td>60 / 100</td>
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<td>HV-LV Impedance at 75 Deg C</td>
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<td>Max. Voltage tap</td>
<td>%</td>
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<td>ii)</td>
<td>Principal tap</td>
<td>%</td>
<td>12.5</td>
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<tr>
<td>iii)</td>
<td>Min. Voltage tap</td>
<td>%</td>
<td>15.4</td>
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<td>iv)</td>
<td>Tolerance on Impedance</td>
<td>%</td>
<td>As per IEC</td>
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<td>Overload Capacity</td>
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<td>IEC 60076-7</td>
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<td>Temperature rise over 50deg C Ambient Temp</td>
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<tr>
<td>i)</td>
<td>Top oil measured by thermometer</td>
<td>ºC</td>
<td>50</td>
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<tr>
<td>ii)</td>
<td>Average winding measured by resistance method</td>
<td>ºC</td>
<td>55</td>
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<td>1.14</td>
<td>Windings</td>
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<td>i)</td>
<td>System Fault level</td>
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<td>HV</td>
<td>kA</td>
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<td>Value</td>
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<td>ii) Lightning Impulse withstand Voltage</td>
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<td>kV&lt;sub&gt;p&lt;/sub&gt;</td>
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<td>LV</td>
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<td>iii) Switching Impulse withstand Voltage</td>
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<td>HV</td>
<td>kV&lt;sub&gt;p&lt;/sub&gt;</td>
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<tr>
<td>iv) One Minute Power Frequency withstand Voltage</td>
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<td>HV</td>
<td>kV&lt;sub&gt;rms&lt;/sub&gt;</td>
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<td>v) Neutral Grounding</td>
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<td>vi) Insulation</td>
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<td>UNIFORM</td>
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<td>vii) Tan delta of winding</td>
<td></td>
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<td>1.15 Vector Group (3 –ph)</td>
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</tr>
<tr>
<td>(unless specified differently elsewhere)</td>
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<tr>
<td>1.16 Tap Changer</td>
<td></td>
<td>OLTC</td>
<td></td>
</tr>
<tr>
<td>i) Tap Range &amp; No. of steps</td>
<td></td>
<td>–15% to +5% of HV variation in the step of 1.25%, 16 steps</td>
<td></td>
</tr>
<tr>
<td>ii) Location of Tap changer</td>
<td></td>
<td>On Neutral side of 132 kV winding</td>
<td></td>
</tr>
<tr>
<td>iii) Design</td>
<td></td>
<td>Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I</td>
<td></td>
</tr>
<tr>
<td>iv) Tap control</td>
<td></td>
<td>Full capacity on load tap changer suitable for group/independent, remote /local electrical and local manual operation and bi-directional power flow.</td>
<td></td>
</tr>
<tr>
<td>1.17 Bushings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Rated voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HV</td>
<td>kV</td>
<td>145</td>
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<td>LV</td>
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<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>kV</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>ii) Rated current (Min.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HV</td>
<td>A</td>
<td>800</td>
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</tr>
<tr>
<td>LV</td>
<td>A</td>
<td>1250</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>A</td>
<td>1250</td>
<td></td>
</tr>
<tr>
<td>iii) Lightning Impulse withstand Voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HV</td>
<td>kV&lt;sub&gt;p&lt;/sub&gt;</td>
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<td></td>
</tr>
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<td></td>
</tr>
<tr>
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<td>kV&lt;sub&gt;p&lt;/sub&gt;</td>
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### One Minute Power Frequency withstand Voltage

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
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<td>kVrms</td>
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<td>77</td>
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### Minimum total creepage distances

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
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<td>900</td>
</tr>
<tr>
<td>Neutral</td>
<td>mm</td>
<td>900</td>
</tr>
</tbody>
</table>

### Tan delta of bushing

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
<td>%</td>
<td>&lt;0.4</td>
</tr>
</tbody>
</table>

### Max Partial discharge level at $U_m$

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
<td>pC</td>
</tr>
</tbody>
</table>

### Max Partial discharge level at $1.5U_m/\sqrt{3}$

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
<td>pC</td>
</tr>
</tbody>
</table>

### Max Noise level at rated voltage and at principal tap on full load and all cooling active

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dB</td>
</tr>
</tbody>
</table>

### Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. The criteria for Transformer losses shall be "Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".

### 7.0 Bushing Current Transformer

7.1 Current transformers shall comply with IEC-60185.

7.2 It shall be possible to remove the turret mounted current transformers from the tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

7.3 Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to cooler control cabinet/marshalling box using separate cables for each core.

7.4 Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Employer's approval before proceeding with the design of bushing current transformers.
### Technical Parameters for Bushing CT

#### Technical Parameters of Current Transformers (for 53.33, 33.33 & 10 MVA 220/132kV 1-Ph Transformer)

<table>
<thead>
<tr>
<th>Description</th>
<th>Current Transformer Parameters (Transformer)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>HV Side</strong></td>
</tr>
<tr>
<td>(a) Ratio</td>
<td></td>
</tr>
<tr>
<td>CORE 1</td>
<td>1000/1</td>
</tr>
<tr>
<td>CORE 2</td>
<td>600/1</td>
</tr>
<tr>
<td>(b) Minimum knee point voltage or burden and accuracy class</td>
<td></td>
</tr>
<tr>
<td>CORE 1</td>
<td>600V, TPS</td>
</tr>
<tr>
<td>CORE 2</td>
<td>0.5 Class</td>
</tr>
<tr>
<td></td>
<td>15VA ISF ≤ 5</td>
</tr>
<tr>
<td>(c) Maximum CT Secondary Resistance</td>
<td></td>
</tr>
<tr>
<td>CORE 1</td>
<td>1.5 Ohm</td>
</tr>
<tr>
<td>CORE 2</td>
<td>-</td>
</tr>
<tr>
<td>(d) Application</td>
<td></td>
</tr>
<tr>
<td>CORE 1</td>
<td>Restricted Earth Fault</td>
</tr>
<tr>
<td>CORE 2</td>
<td>Metering</td>
</tr>
<tr>
<td>(e) Maximum magnetization current (at knee point voltage)</td>
<td></td>
</tr>
<tr>
<td>CORE 1</td>
<td>100 mA</td>
</tr>
<tr>
<td>CORE 2</td>
<td>-</td>
</tr>
</tbody>
</table>

**NOTE:**

i) For TPS class CT's, Dimensioning parameter “K”, Secondary VA shall be considered 1.5 and 20 respectively. Class (for the relevant protection and duties) as per IEC 60185.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.
iv) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

7.5.2 Technical Parameters of Current Transformers (for 40 MVA, 31.5/30 MVA, 25MVA, 20MVA, 12.5MVA 132/33kV 3-Ph Transformers)

<table>
<thead>
<tr>
<th>Description</th>
<th>Current Transformer Parameters (Transformer)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HV Side</td>
</tr>
<tr>
<td>(a) Ratio</td>
<td>CORE 1</td>
</tr>
<tr>
<td></td>
<td>CORE 2</td>
</tr>
<tr>
<td>(b) Minimum knee point voltage or burden and accuracy class</td>
<td>CORE 1</td>
</tr>
<tr>
<td></td>
<td>CORE 2</td>
</tr>
<tr>
<td>(c) Maximum CT Secondary Resistance</td>
<td>CORE 1</td>
</tr>
<tr>
<td></td>
<td>CORE 2</td>
</tr>
<tr>
<td>(d) Application</td>
<td>CORE 1</td>
</tr>
<tr>
<td></td>
<td>CORE 2</td>
</tr>
<tr>
<td>(e) Maximum magnetization current (at knee point voltage)</td>
<td>CORE 1</td>
</tr>
<tr>
<td></td>
<td>CORE 2</td>
</tr>
</tbody>
</table>

NOTE:

i) For TPS class CT’s, Dimensioning parameter “K”, Secondary VA shall be considered 1.5 and 20 respectively. Class (for the relevant protection and duties) as per IEC 60185.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.
iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

8.0 Oil Storage Tank

8.1 General

This specification is for oil storage tank. Oil Storage tank shall be Supplied if specified in Bid Price schedule.

8.2 Standard

The oil storage tank shall be designed and fabricated as per relevant standards.

8.3 Specifications

Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Size of the storage tank shall be as follows:

Diameter : 1.5 meter (For 10 cubic meter capacity)  
2.0 meter (For 20 cubic meter capacity)

Minimum Capacity : As mentioned in BPS

The tank shall be designed for storage of oil at a temperature of 100°C.

8.3.1 The Bidder may further note that maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

8.3.2 The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

8.3.3 The tank shall also fitted with manhole, outside & inside access ladder, silicagel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. Bidder shall indicate the engine capacity in horse power to pull one tank completely fitted with oil. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Suitable arrangement shall also be provided to prevent overflow in the tank. Solenoid valve (Electro-mechanically operated) with centrifugal pump shall be provided at bottom inlet so that pump shall be utilized both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain from the tank.
8.3.4 The following accessories shall form part of supply along with each Oil storage tank.

   i) Four numbers of suitable nominal bore rubber hoses for transformer oil application up to temperature of 100°C, full vacuum and pressure up to 2.5 Kg/cm² with couplers and unions each not less than 10 metre long shall be provided.

   ii) Two numbers of suitable nominal bore vacuum hoses, suitable for full vacuum without collapsing and kinking, with couplers and unions each not less than 10 metre long shall also be provided.

   (iii) One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr operating on 230V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with atleast 8 meter cable so as to suitably place the Vacuum gauge at ground level.

8.3.5 The painting of oil storage tank and its control panel shall be as per clause no 3.1.1.8.

8.3.6 The tank shall contain a self mounted centrifugal oil pump with inlet and outlet valves, with couplers suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 3.0 (For 10 cubic meter capacity) / 6.0 kl/hr (For 20 cubic meter capacity) with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubical with IP-55 enclosure.

9.0 OIL SAMPLING BOTTLE

9.1 Oil sampling bottles shall be suitable for collecting oil samples from transformers and shunt reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

9.2 Oil sampling bottles shall be made of stainless steel having a capacity of one litre.

9.3 Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

9.4 The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.

9.5 An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.
All tests shall be carried out as per IEC: 60076 on transformer.

1) **Magnetic Circuit Test**

After assembly each core shall be tested for 1 minute at 2000 Volts between all bolts, side plates and structural steel work.

2) **Tank Tests**

(i) **Oil Leakage Test**

All tanks and oil filled compartments shall be tested for oil tightness by being completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC-60296 at the ambient temperature and applying a pressure equal to the normal pressure plus 35 KN/Sq.m (5 psi) measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which time no leak shall occur.

(ii) **Vacuum Test**

All transformer tank of each size shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

<table>
<thead>
<tr>
<th>Horizontal Length of flat plate (in mm)</th>
<th>Permanent deflection (in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto and including 750</td>
<td>5.0</td>
</tr>
<tr>
<td>751 to 1250</td>
<td>6.5</td>
</tr>
<tr>
<td>1251 to 1750</td>
<td>8.0</td>
</tr>
<tr>
<td>1751 to 2000</td>
<td>9.5</td>
</tr>
<tr>
<td>2001 to 2250</td>
<td>11.0</td>
</tr>
<tr>
<td>2251 to 2500</td>
<td>12.5</td>
</tr>
<tr>
<td>2501 to 3000</td>
<td>16.0</td>
</tr>
<tr>
<td>Above 3000</td>
<td>19.0</td>
</tr>
</tbody>
</table>

(iii) **Pressure Test**

All transformer tank of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to an air pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/m2 whichever is lower measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

3) **Measurement of capacitance and tan delta**

To determine capacitance between winding and earth. Tan delta value shall not be more than 0.5% corrected at 20deg C. Temperature correction factor table shall be given by the Contractor and shall form the part of test results.

4) **Temp. Rise Test (as per IEC 60076)**

Gas chromatographic analysis on oil shall also be conducted before and after this test and the values shall be recorded in the test report. The sampling shall be in
accordance with IEC 60567. For the evaluation of the gas analysis in temperature rise test the procedure shall be as IEC: 60567 and results will be interpreted as per IEC -61181. The DGA results shall generally conform to IEC/IEEE guidelines.

The temperature rise test shall be conducted at a tap for the worst combination of loading on the three windings of the transformer. The Contractor before carrying out such test shall submit detailed calculations showing alternatives possible, on various taps of the transformer and shall recommend the combination that results in highest temperature rise for the test.

6) **Type Tests on fittings:**

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings. The list of fittings and the type test requirement is:

   a. Bushing (Type Test as per IEC: 60137)
   b. Buchholz relay (Type Test and IP-55 Test on terminal box)
   c. Marshalling box (IP-55 test)
   d. Pressure Relief device Test

The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released. The terminal box / boxes of PRD should conform to degree of protection as per IP-55.

   e. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
   f. Air Cell (Flexible air separator) –Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per BS: 903.
   g. OTI & WTI – Switch setting & operation, switch differential, switch rating.

7) **Inspection and Testing at Site**

The Contractor/Manufacturer shall supervise testing & commissioning at site. Testing & commissioning shall be carried out by the owner (MOEP-2). Contractor shall submit a detailed procedure for Testing & Commissioning at site including receipt, storage & installation checks as mentioned below.

a) **Receipt and Storage Checks**

   • Check and record condition of each package, visible parts of the transformer etc. for any damage.
   • Check and record the gas pressure in the transformer tank as well as in the gas cylinder.
   • Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.
   • Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

b) **Installation Checks**

   • Check whole assembly for tightness, general appearance etc.
- Oil leakage test
- Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.
- Leakage check on bushing before erection.
- Measure and record the dew point of nitrogen/dry air in the main tank before assembly. Manufacturer shall submit dew point acceptable limits along with temperature correction factor and shall form part of instruction manual. In case dew point values are not within permissible limit suitable drying out process shall be applied for dry out of active part in consultation with the Manufacturer.

c) Oil filling

Oil impregnation or drying under vacuum at site shall be done with the transformer and oil at a temperature not exceeding 70°C.

The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method but shall generally not be less than 72 hours. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

Vacuum shall not be broken until the transformer is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete transformer. For this purpose the transformer shall first be drained to expose all insulation material.

The minimum safe level of oil filling (if different from the Buchholz level) to which the transformer shall be oil filled under vacuum, shall be indicated in the manual.

Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

d) Commissioning Checks

- Check the colour of silicagel in silicagel breather.
- Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.
- Check the bushing for conformity of connection to the lines etc,
- Check for correct operation of all protection devices and alarms:
  (i) Buchholz relay.
  (ii) Excessive winding temperature.
  (iii) Excessive oil temperature.
  (iv) Low oil level indication.
- Check for the adequate protection on the electric circuit supplying the accessories.
- Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:
  (i) Control wiring.
  (ii) Main windings.
- Check for cleanliness of the transformer and the surroundings.
- Continuously observe the transformer operation at no load for 24 hours.
- Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.
- Phase out and vector group test.
- Ratio test on all taps.
- Magnetising current test.
- Capacitance and Tan delta measurement of winding and bushing.
- DGA of oil just before commissioning and after 24 hours energisation at site.
ANNEXURE – B

Nitrogen Injection Type Fire Prevention & Extinguishing System

1.1 Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer/reactor tank and the fire during internal faults resulting from arc. The system shall work on the principle of Drain & stir. On activation, it shall drain a predetermined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly). Electrical isolation of transformer shall be an essential pre-condition for activating the system.

1.2 Operational Controls The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

1.2.1 Prevention of transformer from explosion and fire To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

1.2.2 Prevention of transformer from fire In case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

1.3 Operation of System On receiving activation signal, the following shall take place: i) Open the quick opening drain valve to drain the top layer oil ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank iii) Open the Nitrogen regulator valve to inject Nitrogen into the transformer tank to create stirring of oil.

There shall be interlock to prevent activation of the system if the transformer is not electrically isolated. There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

1.4 Technical Particulars The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from owner. Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen. The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/leakage of valve. Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor’s responsibility to further distribute power to the required locations. In case auxiliary DC power supply
requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor. Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box:-

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer/ Reactor
- Oil drain started • Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

1.5 Details of Supply of System Equipments and Other Related Activities: The scope of supply shall include the following items and any other items required for safe and trouble free operation of the system. i) Fire extinguishing cubicle with base frame and containing at least the following:

- Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
- Oil Drain Assembly including oil drain pipe extension of suitable size for connecting pipes to oil pit
- Mechanical release device for oil drain and nitrogen release
- Limit switches for monitoring of the systems
- Panel lighting
- Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
- Back up pressure switch to operate nitrogen gas valve
- Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering. All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

1.6 Under Ground Oil Storage Tank Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non Corrosive, water proof, epoxy coated (from Inside) mild steel (minimum thickness 6 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per Annexure – F. The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor. This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rain water. The design of tank and pit shall be finalised during detailed engineering.

1.7 Installation and pre-commissioning test After installation the system pre-commissioning tests shall be carried out jointly with the Owner’s representative before the system is put in service.

1.8 NIFPS based on alternate proven technology shall also be acceptable.
# CHAPTER 21 – GAS INSULATED SWITCHGEAR

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CHAPTER 21 – GAS INSULATED SWITCHGEAR

1. GENERAL CHARACTERISTICS

1.1. The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of its constituent parts. It should be designed for indoor application with meteorological conditions at site as per Section Project.

1.2. All parts of the switchgear and the bus ducts (for both indoor and outdoor applications) shall be single phase/three phase enclosed for 220kV and three phase enclosed for 132 KV.

1.3. The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The equipment offered shall be protected against all types of voltage surges and any equipment necessary to satisfy this requirement shall be deemed to be included.

1.4. The required overall parameters of GIS are as follows:

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Technical particulars</th>
<th>220 kV System</th>
<th>132kV system</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rated Voltage (RMS)</td>
<td>245 kV</td>
<td>145 kV</td>
</tr>
<tr>
<td>2.</td>
<td>Rated frequency</td>
<td>50 HZ</td>
<td>50 HZ</td>
</tr>
<tr>
<td></td>
<td>Grounding</td>
<td>Effectively earthed</td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>3.</td>
<td>Rated power frequency withstand Voltage (1 min) line to earth (rms)</td>
<td>460 kV</td>
<td>275 kV</td>
</tr>
<tr>
<td>4.</td>
<td>Impulse withstand BIL (1.2/50/mic. Sec) Line to earth</td>
<td>±1050 kVp</td>
<td>±650 kVp</td>
</tr>
<tr>
<td>5.</td>
<td>Rated short time withstand current (1 sec) (As applicable)</td>
<td>40 kA (rms)</td>
<td>31.5kA (rms)</td>
</tr>
<tr>
<td>6.</td>
<td>Rated peak withstand current (as applicable)</td>
<td>125/100 kA (peak)</td>
<td>78.75kA (peak)</td>
</tr>
<tr>
<td>7.</td>
<td>Rated current (at 50 degree C design ambient temperature)</td>
<td>As per BPS</td>
<td></td>
</tr>
</tbody>
</table>

2. REFERENCE STANDARDS

The metal-enclosed gas-insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the following International Electro-technical Commission (IEC) Publications including their parts and supplements as amended or revised as on date of bid opening:

- **IEC 62271-203** Gas Insulated metal-enclosed switchgear for rated voltages above 52 KV
- **IEC 62271-207** Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV
- **IEC 60376** New sulphur hexafluoride
- **IEC 62271-100** High voltage alternating current Circuit breakers
- **IEC 62271-1** Common clauses for high voltage Switchgear and control-gear standards
- **IEC 62271-102** Alternating current disconnectors(isolators) and earthing switches
IEC 60044-1  Current transformers  
IEC 60044-2  Voltage transformers  
IEC 60137  Bushings for alternating voltages above 1000 V  
IEC 62271-209  Cable connections for gas-insulated switchgear  
IEC 60480  Guide to checking of sulphur hexafluoride taken from electrical equipment  
IEC 60099-1/4  Non-linear resistor type arresters for AC systems  
IEC 60439  Factory-built assemblies of low-voltage switchgear and control Gear.  
CIGRE-44  Earthing of GIS - an application guide. (Electra no.151, Dec’93).  
IEC 61639  Direct connection between Power Transformers and gas insulated metal enclosed switchgear for rated voltage 72.5 kV and above.

The components and devices which are not covered by the above standards shall conform to, and comply with, the applicable standards, rules, codes and regulations of the internationally recognized standardizing bodies and professional societies as may be approved by the Owner/consultant and the manufacturer shall list all such applicable standards, codes etc.

In case the requirements laid down herein differ from those given in above standard in any aspect the switchgear shall comply with the requirements indicated herein in regard thereto.

3. DEFINITIONS

3.1. Assembly: Assembly refers to the entire completed GIS equipment furnished under contract.

3.2. Bay: Bay refers to the area occupied by one Circuit Breaker and associated equipment.

3.3. Compartment: When used in conjunction with GIS equipment, compartment refers to a gas tight volume bounded by enclosure walls and gas tight isolating barriers.

3.4. Enclosure: When used in conjunction with GIS equipment, enclosure refers to the grounded metal housing or shell which contains and protects internal Power system equipment (breaker, disconnecting switch, grounding switch, voltage transformer, current transformer, surge arresters, interconnecting bus etc.)


3.6. Module: When used in conjunction with GIS equipment, module refers to a portion of that equipment. Each module includes its own enclosure. A module can contain more than one piece of equipment, for example, a module can contain a disconnecting switch and a grounding switch.

3.7. Reservoir: When used in conjunction with GIS equipment reservoir refers to a larger gas-tight volume.

4. GENERAL DESIGN AND SAFETY REQUIREMENT

4.1. The GIS shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric stress and insulation coordination etc. shall be maintained during design, selection of raw material, manufacturing process etc. so that the GIS provides long life with least maintenance.
The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.

4.2. The GIS assembly shall consist of separate modular compartments e.g. Circuit Breaker compartment, Bus bar compartment filled with SF6 Gas and separated by gas tight partitions so as to minimize risk to human life, allow ease of maintenance and limit the effects of gas leaks failures & internal arcs etc. These compartments shall be such that maintenance on one feeder may be performed without de-energising the adjacent feeders. These compartments shall be designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of a failure occurring within the compartments. Rupture diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting pressures developing within the enclosures under worst operating conditions, thus providing controlled pressure relief in the affected compartment.

4.3. The switchgear, which shall be of modular design, shall have complete phase isolation. The conductors and the live parts shall be mounted on high graded epoxy resin insulators. These insulators shall be designed to have high structural strength and electrical dielectric properties and shall be free of any voids and free of partial discharge at a voltage which is at least 5% greater than the rated voltage. These shall be designed to have high structural and dielectric strength properties and shall be shaped so as to provide uniform field distribution and to minimize the effects of particle deposition either from migration of foreign particles within the enclosures or from the by-products of SF6 breakdown under arcing conditions.

4.4. Gas barrier insulators shall be provided so as to divide the GIS into separate compartments. These shall be suitably located in order to minimize disturbance in case of leakage or dismantling. They shall be designed to withstand any internal fault thereby keeping an internal arc inside the faulty compartment. Due to safety requirement for working on this pressurized equipment, whenever the pressure of the adjacent gas compartment is reduced during maintenance, this compartment shall be designed so that it shall remain in service to perform its intended duty. The gas tight barriers shall be clearly marked on the outside of the enclosures.

The bus enclosure should be sectionalized in a manner that maintenance work on any bus disconnector (when bus and bus disconnector are enclosed in a single enclosure) can be carried out by isolating and evacuating the small effected section and not the entire bus.. The design of 220/132 kV GIS shall be such that in case a circuit breaker module of a feeder is removed for maintenance, both busbars shall remain in service. For achieving the above requirements, adequate Mechanical support and number of intermediate gas tight compartments as required, shall be provided to ensure equipment and operating personnel's safety.

Typical drawings indicating gas tight compartments are enclosed at Annexure-A.

4.5. The material and thickness of the enclosures shall be such as to withstand an internal flash over without burn through for a period of 300 ms at rated short time withstand current. The material shall be such that it has no effect of environment as well as from the by-products of SF6 breakdown under arcing condition.

4.6. Each section shall have plug- in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the equipment. Inspection windows shall be provided for Disconnectors and earth switches.

4.7. The material used for manufacturing the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be
fabricated of aluminum/ copper tubes of cross sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge. The conductor ends shall be silver plated and fitted into finger contacts or tulip contacts. The contacts shall be of sliding type to allow the conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators.

4.8. Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes and based on the design temperature and design pressures as defined in IEC-62271-203.

4.9. The maximum SF6 gas leakage shall not exceed 0.5% (half percent) per year for the whole equipment and for any individual gas compartment separately. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed for at least 10 years. In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during the first year of operation after commissioning.

4.10. Each gas-filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water vapour which may penetrate into the enclosures as well as the by-products of SF6 during interruption. Each gas compartment shall be fitted with non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.

4.11. The switchgear line-up when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations up to the permissible servicing intervals under 100% rated and fault conditions shall not diminish the performance or significantly shorten the useful life of the switchgear. Any fault caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear.

4.12. The thermal rating of all current carrying parts shall be minimum for one sec. for the rated symmetrical short-circuit current.

4.13. The switchgear shall be of the free standing, self-supporting with easy accessibility to all the parts during installation & maintenance with all high-voltage equipment installed inside gas-insulated metallic and earthed enclosures, suitably sub-divided into individual arc and gas-proof compartments preferably for:

   1) Bus bars
   2) Intermediate compartment
   3) Circuit breakers
   4) Line Disconnectors
   5) Voltage Transformers
   6) Gas Insulated bus duct section between GIS and XLPE cable/Overhead Conductor.
   7) Gas Insulated bus section between GIS & Oil filled Transformer (if applicable)

4.14. The arrangement of the individual switchgear bays shall be such so as to achieve optimum space-saving, neat and logical arrangement and adequate accessibility to all external components.

4.15. The layout of the substation equipment, bus bars and switchgear bays shall preferably be based on the principle of “phase grouping”. Switchgear layout based on the “mixed phases” principle shall not be accepted without mutual agreement
between supplier and employer/consultant. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.

4.16. All the elements shall be accessible without removing support structures for routine inspections. The removal of individual enclosure parts or entire breaker bays shall be possible without disturbing the enclosures of neighboring bays.

4.17. It should be impossible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force. All interlocks that prevent potentially dangerous mal-operations, shall be constructed such that they cannot be operated easily, i.e. the operator must use tools or brute force to over-ride them.

4.18. In general the contours of energized metal parts of the GIS and any other accessory shall be such, so as to eliminate areas or points of high electrostatic flux concentrations. The surfaces shall be smooth with no projection or irregularities which may cause visible corona. No corona shall be visible in complete darkness which the equipment is subjected to specified test voltage. There shall be no radio interference from the energized switchgear at rated voltage.

4.19. The GIS shall be designed, so as to take care of the VFT over voltages generated as a result of pre-strikes and re-strikes during isolator operation. Maximum VFT over voltages peak shall not be higher than rated lightning impulse withstand voltage (LIWV) of the equipment. Necessary measures shall be under taken by GIS manufacture to restrict maximum VFT over voltages lower than the LIWV. Manufacturer shall submit the study report of VFTO generated for GIS installation.

4.20. The enclosure shall be of continuous design and shall meet the requirement as specified in clause no. 10 (special considerations for GIS) of IEEE- 80, Year- 2000. The enclosure shall be sized for carrying induced current equal to the rated current of the Bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.

4.21. The fabricated metalenclosures shall be of Aluminum alloy having high resistance to corrosion, low electrical loses and negligible magnetic losses. All joint surfaces shall be machined and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall conform to metric system.

4.22. The elbows, bends, cross and T-sections of interconnections shall include the insulators bearing the conductor when the direction changes take place in order to ensure that live parts remain perfectly centered and the electrical field is not increased at such points.

4.23. The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions. The average intensity of electromagnetic field shall not be more than 50 micro –Tesla on the surface of the enclosure. The contractor shall furnish all calculations and documents in support of the above during detailed engineering.

4.24. The switchgear shall have provision for connection with ground mat risers. This provision shall consist of grounding pads to be connected to the ground mat riser in the vicinity of the equipment.

4.25. The ladders and walkways shall be provided wherever necessary for access to the equipment.

4.26. Wherever required, the heaters shall be provided for the equipment in order to ensure the proper functioning of the switchgear at specified ambient temperatures. The heaters shall be rated for 230V AC supply and shall be complete with thermostat, control switches and fuses, connected as a balanced 3-phase. 4-wire
load. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.

4.27. The enclosure & support structure shall be designed that person of 1780 mm in height and 80 Kg in weight is able to climb on the equipment for maintenance.

4.28. The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.

4.29. Alarm circuit shall not respond to faults for momentary conditions. The following indications including those required elsewhere in the specifications shall be generally provided in the alarm and indication circuits.

**Gas Insulating System:**

i) Loss of Gas Density.

ii) Loss of Heater power(if required)

iii) Any other alarm necessary to indicate deterioration of the gas insulating system.

**Operating System:**

i) Low operating pressure.

ii) Loss of Heater power.

iii) Loss of operating power.

iv) Loss of control supply.

v) Pole Discordance.

4.30. The equipment will be operated under the following ambient conditions(or as defined in the section project):

a) The ambient temperature varies between 0 degree-C and 50 degree-C. However, for design purposes, ambient temperature should be considered as 50 degree-C.

b) The humidity will be about 95% (indoors)

c) The elevation as per section project.

4.31. Temperature rise of current carrying parts shall be limited to the values stipulated in IEC-62271-1, under rated current and the climatic conditions at site. The temperature rise for all enclosures shall not exceed 20 degree C above the ambient temperature of 50 degree C. These conditions shall be taken into account by the supplier in the design of the equipment

4.32. **Bellows or Compensating Units:** Adequate provision shall be made to allow for the thermal expansion of the conductors & enclosures and of differential thermal expansion between the conductors and the enclosures. The bellows metallic( preferably stainless steel) with suitable provision for permitting the movement during expansion and contraction may be provided and shall be of following types:

1. Lateral / Vertical mounting units: These shall be inserted, as required, between sections of busbars, on transformer and XLPE cable etc. Lateral mounting shall be made possible by a sliding section of enclosure and tubular conductors.

2. Axial compensators: These shall be provided to accommodate changes in length of busbars due to temperature variations.

3. Parallel compensators: These shall be provided to accommodate large linear expansions and angle tolerances.

4. Tolerance compensators: These shall be provided for taking up manufacturing, site assembly and foundation tolerances.
5. **Vibration compensators:** These bellow compensators shall be provided for absorbing vibrations caused by the transformers when connected to SF6 switchgear by oil- SF6 bushings.

The electrical connections across the bellows or compensating units shall be made by means of suitable connectors. For sliding type compensators, markers/pointers shall be provided to observe expansion or contraction during climatic conditions.

4.33. **Indication and verification of switch positions:** Indicators shall be provided on all circuit breakers, isolators and earth-switches, which shall clearly show whether the switches are open or closed. The indicators shall be mechanically coupled directly to the main contact operating drive rod or linkages and shall be mounted in a position where they are clearly visible from the floor or the platform in the vicinity of the equipment.

Inspection windows shall also be provided with all isolators and earth switches so that the switch contact positions can be verified by direct visual inspection.

4.34. **Pressure relief device:** Pressure relief devices shall be provided in the gas sections to protect the gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction).

Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction.

If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided. Contractor shall submit to the owner the detailed criteria/design regarding location of pressure relief devices/rupture diaphragms.

4.35. **Pressure vessel requirements:** The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel code (ASME/CENELEC code for pressure Vessel.)

The bursting strength of Aluminum castings has to be at least 5 times the design pressure. A bursting pressure test shall be carried out at 5 times the design pressure as a type test on each type of enclosure.

Each enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute.

4.36. **Grounding:**

4.36.1. The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences.

4.36.2. The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS. The contractor shall supply the entire material for grounding bus of GIS viz conductor, clamps, joints, operating and safety platforms etc. The contractor is also required to supply all the earthing conductors and associated hardware material for connecting all GIS equipment, bus ducts, enclosures, control cabinets, supporting structure, GIS surge arrester etc. to the ground bus of GIS.

4.36.3. The enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The grounding continuity between each enclosure shall be effectively interconnected externally with Copper /Aluminum bonds of suitable size to bridge the flanges. Subassembly to subassembly bonding shall be provided to bridge the gap & safe voltage gradients between all
intentionally grounded parts of the GIS assembly & between those parts and the main grounding bus of the GIS.

4.36.4. Each marshaling box, local control panel, power and control cable sheaths and other non-current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.

4.36.5. The grounding connector shall be of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating. At least two grounding paths shall be provided to connect each point to the main grounding bus. Necessary precautions should be under taken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment.

4.36.6. All flexible bonding leads shall be tinned copper. All connectors, for attaching flexible bonding leads to grounding conductors and grounding conductors to support structures shall be tinned bronze with stainless steel or tinned bronze hardware.

4.36.7. The contractor shall provide suitable measure to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrestor, phase to earth fault and discharges between contacts during switching operation. The grounding system shall ensure safe touch & step voltages in all the enclosures.

4.37. **UHF sensors for PD detection**: Contractor shall provide adequate number of UHF sensors in the offered GIS for detection of Partial discharge (of 5 pC and above) as per IEC 60270 through Partial Discharge (PD) monitoring system and the number and location of these sensors shall be subject to approval of the employer/consultant. Further UHF sensors shall necessarily be provided in close proximity to VT compartments.

However adequacy of number of sensors and their location shall be verified at site by the contractor as per recommendations of CIGRE task force TF 15/33.03.05 *(Task force on Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the acoustic method)*. In case during site testing additional UHF sensors are required, the same shall also be supplied & installed to complete the technical requirement.

4.38. **Gas Insulated Bus (GIB) layout**:

GIB shall be designed based on the following criteria

(1) Maximum weight of gas in a gas tight section of GIB shall not exceed 250 Kg for 220 kV & 132 kV.

(2) GIS bus ducts of each circuit shall be arranged in preferably horizontal formation and the clearance (outer to outer) between nearest bus ducts of two adjacent circuits shall be minimum one (1) meter.

(3) GIB shall be generally in only one horizontal layer. However in exceptional circumstance two horizontal GIB layers can be provided with the approval of Owner/consultant and the vertical clearance between layers shall be minimum one (1) meter in such case.

(4) The minimum outer to outer horizontal clearance between each GIS bus duct shall 0.5 meter for 220 kV & 132 kV voltage level.

(5) The minimum vertical ground clearance of GIB at road crossing shall be 5.5 meters

(6) The horizontal clearance between GIB and GIS building /any other building wall shall be minimum three (3) meters.
(7) The GIB route inside the GIS Hall shall not obstruct easy access to GIS and control room buildings and shall not obstruct movement of crane, equipment including HV test equipment for maintenance works.

(8) The GIB height outside the GIS hall in switchyard area shall not obstruct easy access to GIB, movement of crane for maintenance work.

(9) Optimisation of outdoor GIB length using overhead AIS connection with Bus Post Insulator of respective voltage class is generally acceptable subject to meeting the electrical clearances as stipulated.

(10) For the maintenance of GIB of one circuit, only that circuit shall be isolated

4.39. A portable ladder with adjustable height shall be supplied to access the GIS equipment for O&M purpose.

4.40. Extension of GIS

4.40.1. The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays.

4.40.2. As the GIS is likely to be extended in future, the contractor shall make available during detailed engineering stage, the complete design detail of interface module such as cross section, enclosure material, enclosure dimensions (inner & outer), Flange diameter (inner & outer), conductor connection arrangement, bolt spacing & dimension, rated gas pressure etc. Further GIS manufacturer supplying GIS under present scope shall furnish all the required details in addition to mentioned above necessary for design and successful implementation of an interface module during later stage while extending GIS by any other GIS manufacturer, without any help of GIS manufacturer who has supplied the GIS equipment in present scope.

4.40.3. The Interface module shall be designed to provide Isolating link with access hole on enclosure. The Isolating link shall be provided in such a way so that HV test can be performed on either side of the interface module separately, keeping other side of GIS remain isolated.

4.40.4. Further the contractor who is extending the existing GIS installation shall optimally utilize the space inside the GIS hall (including the extension portion) for accommodating the interface module being supplied under the contract and the space (along the length of the hall) inside the GIS hall for interface module shall preferably be limited to 1 meter for 220/132kV

4.41. SF6 GAS

The SF6 gas insulated metal-clad switchgear shall be designed for use with SF6 gas complying with the recommendations of IEC 376, 376A & 376B, at the time of the first charging with gas. All SF6 gas supplied as part of the contract shall comply with the requirements of IEC as above as a minimum & should be suitable in all respects for use in the switchgear under all operating conditions.

The high pressure cylinders in which SF6 gas is supplied & stored at site shall comply with the requirements of following standards & regulations:

- **IS : 4379** Identification of the contents of industrial gas cylinders.
- **IS : 7311** Seamless high carbon steel cylinders for permanent & high pressure liquefiable gases. The cylinders shall also meet Indian Boilers Regulations. (Mandatory)

SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water contents as per IEC:376, 376A & 376B and test certificates shall be furnished to the
owner indicating all test results as per IEC standards for each lot of SF6 gas. Further site tests for moisture, air content, flash point and dielectric strength to be done during commissioning of GIS. Gas bottles should be tested for leakage during receipt at site.

The contractor shall indicate diagnostic test methods for checking the quality of gas in the various sections during service. The method proposed shall, as a minimum check the moisture content & the percentage of purity of the gas on annual basis.

The contractor shall also indicate clearly the precise procedure to be adopted by maintenance personnel for handling equipment that are exposed to the products of arcing in SF6 Gas so as to ensure that they are not affected by possible irritants of the skin and respiratory system. Recommendations shall be submitted for suitable protective clothing, method of disposal of cleaning utensils and other relevant matters.

The contractor shall also indicate the details and type of filters used in various gas sections, and should also submit the operating experience with such filters.

4.41.1. **SF6 gas monitoring devices and alarm circuits:** Dial type temperature compensated gas density monitoring devices with associated pressure gauge will be provided. The devices shall provide continuous & automatic monitoring of gas density & a separate device shall be provided for each gas compartment so that each compartment can be monitored simultaneously as follows:

<table>
<thead>
<tr>
<th>Compartment/ Sl no</th>
<th>Compartments except CB</th>
<th>Circuit Breaker compartments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&quot;Gas Refill level&quot;: This will be used to annunciate the need for the gas refilling. The contractor shall provide a contact for remote indication.</td>
<td>'Gas Refill' level :This will be used to annunciate the need for gas refilling. The contractor shall provide a contact for remote indication.</td>
</tr>
<tr>
<td>2</td>
<td>&quot;SF6 low level&quot;: This will be used to annunciate the need for urgent gas filling . A contact shall be provided for remote indication</td>
<td>&quot;SF6 low level&quot; : This will be used to annunciate the need for urgent gas filling. A contact shall be provided for remote indication</td>
</tr>
<tr>
<td>3</td>
<td>'Zone Trip' level: This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly.</td>
<td>Breaker Block' level : This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker .At this level the breaker block contact shall operate and the closing &amp; tripping circuit shall be blocked</td>
</tr>
<tr>
<td>4</td>
<td>Not Applicable</td>
<td>'Zone Trip' level: This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly.</td>
</tr>
</tbody>
</table>

The density monitor/pressure switch contacts shall be in accordance with the above requirement.
4.41.2. The contractor should furnish temperature v/s pressure curves for each setting of density monitor along with details of the monitoring device. It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

4.41.3. **Gas Supply:** The contractor shall include the supply of all SF6 gas necessary for filling & putting into operation the complete switchgear installation being supplied. The empty gas cylinders shall be returnable to the contractor.

5. **CIRCUIT BREAKERS**

5.1. **General:** SF6 gas insulated metal enclosed circuit breakers shall comply with the latest revisions of IEC-62271-100 & relevant IEC except to the extent explicitly modified in the specification and shall meet with requirements specified. Circuit breakers shall be equipped with the operating mechanism. Circuit breakers shall be of single pressure type. Complete circuit breaker with all necessary items for successful operation shall be supplied. The circuit breakers shall be designed for high speed single and three phase reclosing with an operating sequence and timing as specified.

5.2. **Duty Requirements:** Circuit breaker shall be C2 - M2 class as per IEC 62271-100. Circuit breaker shall meet the duty requirements for any type of fault or fault location also for line charging and dropping when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

5.3. The circuit breaker shall be capable of:

1. Interrupting the steady and transient magnetizing current shall be as follows:

<table>
<thead>
<tr>
<th>Voltage Level</th>
<th>Type of Transformer</th>
<th>Rating in MVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>220kV</td>
<td>220/132 kV</td>
<td>33.33 to 200</td>
</tr>
<tr>
<td>132kV</td>
<td>132/11kV</td>
<td>10 to 50</td>
</tr>
</tbody>
</table>

2. Interrupting line/cable charging current as per IEC without re-strikes and without use of opening resistors. The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of U/\sqrt{3} and 1.4

3. Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

4. Breaking 25% the rated fault current at twice the rated voltage under phase opposition condition.

5. The breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of shunt reactor and/or series capacitor compensated lines with trapped charges.

6. Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).
5.4. **Total Break Time**: The total break time shall not be exceeded under any of the following duties:

a) Test duties T10, T30, T60, T100 (with TRV as per IEC-62271-100)
b) Short line fault L90, L75 (with TRV as per IEC-62271-100)

The Contractor may please note that the total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), pneumatic/hydraulic pressure and SF6 gas pressure etc. While furnishing the proof for the total break time of complete circuit breaker, the contractor may specifically bring out the effect of non-simultaneity between poles and show how it is covered in the total break time.

The values guaranteed shall be supported with the type test reports.

5.5. **Constructional features**: The features and constructional details of breakers shall be in accordance with requirements stated hereunder:

5.5.1. **Contacts**: All making and breaking contacts shall be sealed and free from atmospheric effects. Contacts shall be designed to have adequate thermal and current carrying capacity for the duty specified and to have a life expectancy so that frequent replacement due to excessive burning will not be necessary. Provision shall be made for rapid dissipation of heat generated by the arc on opening.

5.5.2. Any device provided for voltage grading to damp oscillations or, to prevent re-strike prior to the complete interruption of the circuit or to limit over voltage on closing, shall have a life expectancy comparable of that of the breaker as a whole.

5.5.3. Breakers shall be so designed that when operated within their specified rating, the temperature of each part will be limited to values consistent with a long life for the material used. The temperature rise shall not exceed that indicated in IEC-62271-100 under specified ambient conditions.

5.5.4. The gap between the open contacts shall be such that it can withstand atleast the rated phase to ground voltage for eight hours at zero pressure above atmospheric level of SF6 gas due to its leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 pu. power frequency voltage across the breaker continuously).

5.5.5. In the interrupter assembly there shall be an adsorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas decomposition products.

5.5.6. Provisions shall be made for attaching an operational analyzer to record travel, speed and making measurement of operating timings etc. after installation at site. The contractor shall supply three set of transducer for each substation covered under the scope.

5.5.7. Circuit Breaker shall be supplied with auxiliary switch having additional 8 NO (normally open) and 8 NC (normally closed) contacts for future use over and above those required for switchgear interlocking and other control and protection function. These spare NO and NC contacts shall be wired up to the local control cubicle.

5.6. **Operating mechanism**

5.6.1. General Requirements:

a) Circuit breaker shall be operated by spring charged mechanism or electro hydraulic mechanism or a combination of these. The mechanism shall be housed in a dust proof cabinet and shall have IP: 42 degree of protection.
b) The operating mechanism shall be strong, rigid, not subject to rebound or to critical adjustments at site and shall be readily accessible for maintenance.

c) The operating mechanism shall be suitable for high speed reclosing and other duties specified. During reclosing the breaker contacts shall close fully and then open. The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.

d) The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.

e) A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided.

f) Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

g) The contractor shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker.

5.6.2. Control

a) The close and trip circuits shall be designed to permit use of momentary-contact switches and push buttons.

b) Each breaker pole shall be provided with two (2) independent tripping circuits and trip coils which may be connected to a different set of protective relays.

c) The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the breaker control cabinet.

d) The trip coil shall be suitable for trip circuit supervision during both open and close position of breaker.

e) Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip and associated circuits shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.

f) Densimeter contacts and pressure switch contacts shall be suitable for direct use as permissive in closing and tripping circuits. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies shall be monitored for remote annunciations and operation lockout in case of dc failures.

g) The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

5.6.3. Spring operated Mechanism

a) Spring operated mechanism shall be complete with motor in accordance with Section GTR. Opening spring and closing spring with limit switch for automatic
charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it required preferably not more than 90 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall automatically be charged for the next operation and an indication of this shall be provided in the local control cabinet & SAS.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition.

h) Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in the closed position.

i) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

5.6.4. **Hydraulically Operated Mechanism:**

a) Hydraulically operated mechanism shall comprise of operating unit with power cylinder, control valves, high and low pressure reservoir, motor etc.

b) The hydraulic oil used shall be fully compatible for the temperature range to be encountered during operation.

c) The oil pressure switch controlling the oil pump and pressure in the high pressure reservoir shall have adequate no. of spare contacts, for continuous monitoring of low pressure, high pressure etc. at switchyard control room.

d) The mechanism shall be suitable for at-least two close open operations after failure of AC supply to the motor starting at pressure equal to the lowest pressure of auto reclose duty plus pressure drop for one close open operation.

e) The mechanism shall be capable of operating the circuit breaker correctly and performing the duty cycle specified under all conditions with the pressure of hydraulic operated fluid in the operating mechanism at the lowest permissible pressure before make up.

f) Trip lockout shall be provided to prevent operations of the circuit breaker below the minimum specified hydraulic pressure. Alarm contacts for loss of Nitrogen shall also be provided.

g) All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage.

5.7. The technical parameters of Circuit breakers are as per Annexure -1

5.8. **Additional data to be furnished during detailed engineering:**
a) Drawing showing contacts in close, arc initiation, full arcing, arc extinction and open position.

b) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100 fault currents to load currents of the lowest possible value without requiring any maintenance or checks.

c) Curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage and hydraulic pressure.

5.9. Tests:

5.9.1. Type Tests:

i. In accordance with the requirements stipulated under Section GTR the circuit breaker along with its operating mechanism shall conform to the type tests as per IEC-62271-100.

ii. The type test report of Electromagnetic Compatibility Test (EMC) of CSD shall be submitted for approval

5.9.2. Routine Tests:

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers. In addition to the mechanical and electrical tests specified by IEC, the following shall also be performed.

i. Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage, pneumatic pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be provided.

ii. Functional tests are to be carried out on circuit breaker along with Control Switching device (CSD).

iii. DCRM (Dynamic Contact Resistance Measurement) to be carried out for all CBs during routine test.

6. DISCONNECTORS (ISOLATORS)

6.1. Disconnectors shall be three-pole group operated or Single-pole individual operated (as per single line diagram of the substation/section project) and shall be installed in the switchgear to provide electrical isolation. The disconnectors shall conform to IEC-62271-102 and shall have the ratings as specified in BPS.

6.2. Construction & Design.

6.2.1. The disconnectors shall be operated by electric motor suitable for use on DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit.

6.2.2. Disconnectors shall be suitable to switch the bus charging currents during their opening and closing and shall confirm to all three test duties viz TD1,TD2 and TD3 as per Annexure –F of IEC: 62271-102. They shall also be able to make and break rated bus transfer current at rated bus transfer voltage which appears during transfer between bus bars in accordance with Annexure –B of IEC: 62271-102. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.

6.2.3. The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to
withstand starting torque of the motor mechanism without damage until the motor overload protection operates.

6.2.4. It shall be possible to operate the disconnecting switches manually by cranks or hand wheels. The contacts shall be both mechanically and electrically disconnected during the manual operation.

6.2.5. The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.

6.2.6. The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located in the Local Control Cabinet (LCC).

6.2.7. Remote control of the disconnectors from the control room/SAS shall be made by means of remote/local transfer switch.

6.2.8. The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.

6.2.9. Each disconnector shall be supplied with auxiliary switch having additional 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for future use over and above those required for switchgear interlocking and automation purposes. These spare NO and NC contacts shall be wired up to the local control cabinet.

6.2.10. The signaling of the closed position of the disconnector shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short-time withstand current can be carried safely.

6.2.11. The signaling of the open position of the disconnector shall not take place unless the movable contacts have reached such a position that the clearance between the contacts is at least 80 percent of the rated isolating distance.

6.2.12. The disconnectors and safety grounding switches shall have a mechanical and electrical inter-locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is in the closed position. Integrally mounted lock when provided shall be equipped with a unique key for such three phase group. Master key is not permitted.

6.2.13. The local control of the Isolator and high-speed grounding switches from the Local Control Cabinet (LCC) should be achieved from the individual control switches with the remote/local transfer switch set to local.

6.2.14. All electrical sequence interlocks will apply in both remote and local control modes.

6.2.15. Each disconnector shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the local control cubicle (LCC) and provisions for taking the signals to the control room. The details of the inscriptions and colouring for the indicator are given as under:

<table>
<thead>
<tr>
<th>INSCRIPTION</th>
<th>COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open position</td>
<td>OPEN</td>
</tr>
<tr>
<td>Closed position</td>
<td>CLOSED</td>
</tr>
</tbody>
</table>

6.2.16. All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure.
6.2.17. The disconnecting switches shall be provided with rating plates and shall be easily accessible.

6.2.18. The mechanical endurance class shall be M2 as per IEC for 765kV, 400kV and 220kV and it shall be M1 class for 132kV disconnectors.

6.2.19. Mechanical position indication shall be provided locally at each disconnector and Electrical indication at each Local Control Cabinet (LCC) / SAS.

6.3. The technical parameters of disconnectors are as per Annexure-2

7. SAFETY GROUNDING SWITCHES

7.1. Safety grounding switches shall be three-pole group operated or single-pole individual operated (as per single line diagram of the substation/section project). It shall be operated by DC electric motor and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over-current and short circuit.

7.2. Each safety grounding switch shall be electrically interlocked with its associated disconnectors and circuit breaker such that it can only be closed if both the circuit breaker and disconnectors are in open position. Safety grounding switch shall also be mechanically key interlocked with its associated disconnectors.

7.3. Each safety grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control room.

7.4. The details of the inscription and colouring for the indicator are given as under:

<table>
<thead>
<tr>
<th>INSCRIPTION</th>
<th>COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open position</td>
<td>OPEN</td>
</tr>
<tr>
<td>Closed position</td>
<td>CLOSED</td>
</tr>
</tbody>
</table>

7.5. Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.

7.6. Each ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others over and above those required for local interlocking and position indication purposes.

7.7. Provision shall be made for padlocking / suitable locking arrangement for the ground switches in either the open or closed position.

7.8. All portions of the grounding switch and operating mechanism required for grounding shall be connected together utilizing flexible copper conductors having a minimum cross-sectional area of 100 sq. mm.

7.9. The main grounding connections on each grounding switch shall be rated to carry the full short circuit current for 1 sec. and shall be equipped with a silver-plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

7.10. The safety grounding switches shall conform to the requirements of IEC- 62271- 102 and shall have electrical endurance class: E0 & shall have mechanical endurance class M1 for 220/132 kV voltage level.

7.11. Combined Disconnectors & Safety grounding switch arrangement shall also be acceptable.
7.12. Mechanical position indication shall be provided locally at each switch and Electrical indication at each Local Control Cabinet (LCC) / SAS.

7.13. Continuous current rating of the grounding switches (not less than 100A) shall be specified by the manufacturer, which can be safely injected for Bay/ Bus equipment testing.

8. **HIGH SPEED MAKE PROOF GROUNDING SWITCHES:**

8.1. Grounding switches located at the beginning of the line feeder bay modules shall be of the high speed, make proof type and will be used to discharge the respective charging currents, trapped charge in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive and capacitive currents and to withstand the associated TRV. These shall confirm to class B and electrical endurance class E1 as per annexure – C of IEC : 62271-102

8.2. High Speed Grounding switches shall be provided with individual/three pole operating mechanism suitable for operation from DC.

8.3. The switches shall be fitted with a stored energy closing system to provide fault making capacity.

8.4. The short circuit making current rating of each ground switch shall be at least equal to its peak withstand current rating as stated in clause 1.4 above. The switches shall have inductive/ capacitive current switching capacity as per IEC-62271-102.

8.5. Each high speed make proof grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the Local Control Cabinet (LCC) and provision for taking the signal to Control Room/SAS.

8.6. The details of the inscription and colouring for the indicator shall be as under:

<table>
<thead>
<tr>
<th>INSCRIPTION</th>
<th>COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open position</td>
<td>OPEN</td>
</tr>
<tr>
<td>Closed position</td>
<td>CLOSED</td>
</tr>
</tbody>
</table>

8.7. High speed ground switch operation should be possible locally from Local Control Cabinet (LCC)

8.8. These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches cannot be closed if disconnectors are closed. Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.

8.9. Each high speed ground switch shall be fitted with auxiliary switches having 4 NO (Normally Open) and 4 NC (Normally Closed) contacts for use by others, over and above these required for local interlocking and position indication. All contacts shall be wired to terminal blocks in the Local Control Cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.

8.10. All portion of the grounding switches and operating mechanism required for connection to ground shall be connected together utilizing copper conductor having minimum cross-sectional area of 100 sq. mm.

8.11. The main grounding connection on each grounding switch shall be rated to carry the peak withstand current rating of the switch for 1 sec. and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate design for connection to the grounding grid.

8.12. The high speed make proof grounding switches shall confirm to the requirements of IEC-62271-102.
8.13. Continuous current rating of the High speed grounding switches (not less than 100A) shall be specified by the manufacturer, which can be safely injected for Bay/ Bus equipment testing.

9. **INSTRUMENT TRANSFORMERS**

9.1. **Current Transformers**

The current transformers and accessories shall conform to IEC: 60044-1 and other relevant standards except to the extent explicitly modified in the specification.

9.1.1. **Ratios and Characteristics:** The CT core distribution for various voltage levels shall be as per Table 3. Further the numbers of cores, rating, ratios, accuracy class, etc. for the individual current transformers secondary cores shall be in accordance with above table.

Where multi-ratio current transformers are required the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

9.1.2. **Rating and Diagram Plates:** Rating and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated extended current rating voltage and rated thermal current shall also be marked on the name plate.

The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

The position of each primary terminal in the current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of the current transformer.

9.1.3. **Constructional Details:**

a) The current transformers incorporated into the GIS will be used for protective relaying and metering purposes and shall be of metal-enclosed type.

b) Each current transformer shall be equipped with a secondary terminal box with terminals for the secondary circuits, which are connected to the Local Control Cubicle. The star/delta configuration and the interconnection to the line protection panels will be done at the CT terminal block located in the local control cubicle.

c) Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

d) For 245/145 kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs as specified in the Section – Project.

e) For 245/145 kV current transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120% (or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

f) The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably built in construction of the CTs.

g) The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the Secondary terminal box.

h) The current transformers shall be suitable for high speed auto-reclosing.
i) Provisions shall be made for primary injection testing either within CT or outside.

j) All the current transformers shall have effective electromagnetic shields to protect against high frequency transients. Electromagnetic shields to be provided against high frequency transients typically 1-30 MHz.

9.2. VOLTAGE TRANSFORMERS

The voltage transformers shall conform to IEC- 60044-2 and other relevant standards except to the extent explicitly modified in the specification.

Voltage transformers shall be of the electromagnetic type with SF6 gas insulation. The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box.

9.2.1. Ratios and Characteristics: The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with annexure -4 & Table 4

9.2.2. Rating and diagram plates : Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

9.2.3. Secondary Terminals, Earthing

The beginning and end of each secondary winding shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF6 switchgear.

All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Provision shall be made for earthing of the secondary windings inside the terminal box.

9.2.4. The transformer shall be able to sustain full line to line voltage without saturation of transformer.

9.2.5. Constructional Details of Voltage Transformers :

a) The voltage transformers shall be located as a separate bay module and will be connected phase to ground and shall be used for protection, metering and synchronization.

b) The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients. The supplier shall ensure that there is no risk of Ferro resonance due to the capacitance of the GIS.

c) The voltage transformers shall have three secondary windings.

d) Voltage transformers secondary shall be protected by Miniature Circuit breakers (MCBs) with monitoring contacts for all the windings. The secondary terminals of the VT’s shall be terminated to preferably stud type non-disconnecting terminal blocks in the secondary boxes via the fuse.

e) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.

f) The accuracy of 0.2 on secondary III should be maintained throughout the entire burden range up to 50 VA on all the three windings without any adjustments during operation.

g) The diagram for the interconnection of the VTs shall be provided inside secondary terminal box.

9.3. Tests:
Current and voltage transformers shall conform to type tests and shall be subjected to routine test in accordance with IEC.

10. **SURGE ARRESTORS**

10.1. The surge arrestors shall confirm in general to latest IEC –60099-4.

10.2. **Insulation co-ordination and selection of surge arrestor:** The contractor shall be fully responsible for complete insulation co-ordination of switchyard including GIS. Contractor shall carry out detailed studies and design calculations to evolve the required parameters locations, energy capability etc. of surge arrestors such that adequate protective margin is available between peak impulse, surge and power frequency discharge voltages and BIL of the protected requirement. The locations of surge arrestors shown in single line diagram is indicative only. If the contractor feels that at some more locations the surge arrestors are required to be provided the same should also be deemed included in the offer.

The contractor shall perform all necessary studies and the report shall detail the limits of all equipment parameters which could affect the insulation co-ordination. The report shall also detail the characteristics of the surge arrestor and shall demonstrate that the selected arrestor’s protective and withstand levels, discharge and coordinating currents and arrester ratings and comply with the requirement of this specification.

The contractor shall also consider in the studies the open circuit breaker condition, fast transients generated by slow operation of disconnecting switches. The study report and design calculations shall be submitted for Owner’s approval.

10.3. **Duty requirements of GIS Surge Arrester**

10.3.1. The surge arrester shall be of heavy duty station class and gapless (Metal oxide) type without any series or shunt gaps.

10.3.2. The surge arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.

10.3.3. 245 & 145kV class arrester shall be capable of discharging energy equivalent to class 3 of IEC for 245 kV & 145 kV system respectively on two successive operations.

10.3.4. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

10.3.5. The surge arresters are being provided to protect the followings whose insulation levels are indicated in the table given below:

<table>
<thead>
<tr>
<th>Equipment to be protected</th>
<th>220KV system</th>
<th>132KV system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lightning impulse (kVp)</td>
<td>Lightning impulse (kVp)</td>
</tr>
<tr>
<td>Power Transformer</td>
<td>± 950</td>
<td>± 550</td>
</tr>
<tr>
<td>Instrument Transformer</td>
<td>± 1050</td>
<td>± 650</td>
</tr>
<tr>
<td>Reactor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CB/Isolator Phase to ground</td>
<td>± 1050</td>
<td>± 650</td>
</tr>
<tr>
<td>CB/Isolator Across open contacts</td>
<td>± 1200</td>
<td>± 750</td>
</tr>
</tbody>
</table>
10.3.6. **Constructional Features**

The nonlinear blocks shall be of sintered/infered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

The arrester enclosure shall be vertically or horizontally mounted to suit the layout of the switchgear as suggested by the supplier and each arrester shall be fitted with a Online continuous resistive leakage current monitoring system. The system shall be provided with an interface to integrate with the substation automation system.

The main grounding connection from the surge arrester to the earth shall be provided by the contractor. The size of the connecting conductor shall be such that all the energy is dissipated to the ground without getting overheated.

10.4. **Tests**

10.4.1. In accordance with the requirements stipulated, the surge arrestors shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC document.

10.4.2. Each metal oxide block shall be tested for the guaranteed specific energy capability in addition to the routine/acceptance test as per IEC-60099.

10.4.3. Test on Surge Monitors: The Surge monitors shall also be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/functional tests with one 100A and 10 kA current impulse, (8/20 micro sec.) shall also be performed on the surge monitor.

10.5. **Technical Parameters**: Technical parameters are as per annexure 5;

11. **OUTDOOR BUSHINGS**:

Outdoor bushings, for the connection of conventional external conductors to the SF6 metal enclosed switchgear, shall be provided where specified and shall conform to the requirements given in GTR.

The dimensional and clearance requirements for the metal enclosure will be the responsibility of the manufacturer and their dimensions must be coordinated with the switchgear.

Bushings shall generally be in accordance with the requirements of IEC -60137.

11.1. Insulation levels and Creepage distances: All bushings shall have an impulse and power frequency withstand level that is greater than or equal to the levels specified for GIS.

The creepage distance over the external surface of outdoor bushings shall not be less than 25 mm/kV and in highly polluted area it shall not be less than 31mm/kV (as per section- Project).

11.2. **Bushing types and fitting**: The details of bushing shall be as follows

SF6 to air Bushing shall be of Polymer / composite type and shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137. All details of the bushing shall be submitted for approval and design review.

Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences,
external pollution and humidity. The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test).

11.3. **Mechanical forces on bushing terminals:** Outdoor bushings must be capable of withstanding cantilever forces due to weight of bus duct (GIB) on one side & AIS conductor/Al tube on the other side and short circuit forces. Design calculations in support of the cantilever strength chosen shall be submitted for owners review and approval.

11.4. Type test reports as per applicable IEC including radio interference voltage (RIV) test shall be submitted in line with the requirement as specified in section GTR for approval.

11.5. The technical parameters of Bushing are as per Annexure -6

12. **SF6 GIS TO XLPE CABLE TERMINATION (If Applicable)**

12.1. The underground cables shall be connected to GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure.

12.2. The SF6 GIS to XLPE cable termination shall conform to IEC-62271-209.

12.3. The rating of XLPE cables for different voltages are specified in the Section project.

12.4. Cable termination kit shall be in the scope of the contract. The ducts and the casing shall be suitable for the requirements for which it is designed. This interface section shall be designed in a manner which will allow ease of operation and maintenance.

12.5. The provision shall be made for a removable link. The gap created when the link is removed should have sufficient electric strength to withstand the switchgear high voltage site tests. The contractor may suggest alternative arrangements to meet these requirements. The corona rings/stress shields for the control of electrical field in the vicinity of the isolation gap shall be provided by the GIS manufacturer.

12.6. All supporting structures for the SF6 bus-duct connections between the XLPE cable sealing ends and the GIS shall be the scope of the contract. The supplier may specify alternative connecting & supporting arrangements for approval of the purchaser.

12.7. The opening for access shall be provided in each phase terminal enclosures as necessary to permit removal of connectors to isolate the XLPE cables to allow carrying out the insulation tests. The general arrangement drawing of interconnecting bus-duct from GIS bay module to XLPE cable termination end shall also be submitted.

12.8. Type test reports of radio interference voltage (RIV) level shall be submitted for approval.

13. **TRANSFORMER TERMINATION MODULE (If applicable)**

13.1.1. The transformer termination module enables a direct transition from the SF6 gas insulation to the bushing of an oil-insulated transformer / reactor. For this purpose, the transformer/reactor bushing must be oil-tight, gas-tight and pressure resistant. Any temperature related movement and irregular setting of the switchgear’s or transformer’s/reactor’s foundations are absorbed by the expansion fitting.

13.1.2. The oil filled transformers and reactors are as shown in the substation SLD. The oil to air bushings of the transformers and reactors shall be supplied by the respective supplier’s and the same shall be connected to the SF6 ducts thru air to SF6 bushings to be provided under present scope.
13.1.3. Terminal connection arrangement to connect GIS duct to bushing and duct mounting arrangement details shall be submitted during detailed engineering for Employer's/consultant approval and for co-ordination with transformer and reactor supplier. Any modification suggested by autotransformer and reactor supplier shall have to be carried out by the supplier to facilitate proper connection with the bushings of the autotransformer and reactors.

13.1.4. In case of single phase transformers are being installed in the substation, HV &LV auxiliary bus for the transformer bank for connecting spare unit shall be formed inside the GIS.

14. LOCAL CONTROL CUBICLE (LCC)

14.1. Functions

14.1.1. Each circuit-breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and semaphore for status indication of the circuit-breaker and all associated isolators and earth switches together with selector switches to prevent local and remote and supervisory controls being in operation simultaneously.

14.1.2. Status indications in the LCC shall be semaphore type or LED type.

14.1.3. Closing of the circuit-breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Circuit-breaker control position selector, operating control switch and electrical emergency trip push button shall be installed in the Local Control Cubicle. Circuit-breaker control from this position will be used under maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.

14.1.4. If Disconnector or earth switch is not in the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.

14.1.5. 20% spare terminals shall be provided in each LCC apart from terminals provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and main power supply etc.

14.1.6. Where plugs and sockets connect control cabling between the local control cubicle and the switchgear these shall not be interchanged.

14.1.7. Hydraulic/pneumatic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breaker, isolators and earth switches shall be located in a separate cubicle compartment.

14.1.8. LCC shall be suitable for remote operation from substation automation system (SAS). Each gas tight compartment shall be monitored individually per phase basis through SAS.

14.2. Constructional features

14.2.1. Local Control cubicle shall be either mounted on the GIS with front access or free standing, floor mounting type. It shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

14.2.2. Access to all compartments shall be provided by doors. All fastenings shall be integral with the panel or door and provision made for locking. Cubicles shall be well ventilated through vermin-proof louvers having anti insect screen. All doors shall be gasketed all around with suitably profiled Neoprene/EPDM gaskets.
conforming with provision of IS 11149. However, XLPE gaskets can also be used for fixing protective glass doors.

14.2.3. Each LCC panel should have its own separate AC supply source feed from the ACDB. The DC supply shall be from respective relay & protection panel power, control, interlocking, signaling. Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. All fuses shall be HRC cartridge type mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.

14.2.4. Each LCC Panel shall be provided with the following

1. **Plug Point**: 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.

2. **Interior Lighting**: Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

3. **Space Heater**: Each panel shall be provided with a thermostatically connected space heater rated for 230V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit

14.2.5. Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles.

14.2.6. Local control cubicles shall be provided to be free standing and shall be equipped with anti-condensation heaters. A suitable humidity stat and thermostat shall be included in the heater circuit.

14.2.7. The interior of each cubicle shall be finished with a semi gloss white surface. An interior lamp suitable for the local LVAC supply, controlled by a door-operating switch, shall be fitted at the top of each panel.

14.2.8. The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus. All the control switches shall be internal i.e. installed behind a lockable glass door.

14.2.9. An interlocking scheme shall be provided that takes into account the following basic requirements.

- To safeguard maintenance personnel who may be working on one section of the equipment with other sections live.
- prevent incorrect switching sequences that could lead to a hazardous situation to plant, equipment and personnel.

14.2.10. Electrical bolt interlocks shall be energized only when the operating handle of the mechanism is brought to the working position. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

14.2.11. Where key interlocking is employed tripping of the circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local
emergency-tripping device shall be kept separate and distinct from the key interlocking.

14.2.12. Disconnecting switches shall be so interlocked that they cannot be operated unless the associated circuit-breaker is open except that where double bus bar arrangements are specified, on-load transfer of feeder circuits from one bus bar to another shall be made possible by interlocks which ensure that the associated bus coupler and its isolators are closed.

14.2.13. Bus coupler circuit breaker shall be interlocked so that it shall not be possible to open a bus coupler circuit breaker while on load change over on that side of the breaker is in progress.

14.2.14. All isolating devices shall be interlocked with associated circuit-breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

15. GIS BUILDING

15.1. The buildings shall house each voltage class Gas Insulated Switchgear (GIS) separately and other associated equipment inside in each of the GIS buildings. GIS building(s) shall be constructed for the specified number of bays/diameters as per section project.

15.2. Wherever GIS hall of proposed voltage is already existing, then the existing GIS hall of respective class shall be suitably extended (wherever applicable) to accommodate the number of bays/diameters as specified in the Section Project.

15.3. The contractor shall submit the design & construction proposal of the building along with necessary information, data, and drawings during the detailed engineering according to the complete requirements.

15.4. The area for GIS hall(s) is indicated in the enclosed General Arrangement drawing. The area given is for reference only and may vary according to requirement of the equipment to be installed inside. The contractor shall finalize the dimensions according to the equipment offered by them providing enough space & access for erection, operation and maintenance.

15.5. The contractor shall place their panels i.e. Bay level units, bay mimic, relay and protection panels, RTCC panels, PLCC panels etc. in a separate room in the GIS building. The size of the room shall be such that all the panels for the future bays/diameters as per clause 15.1 shall be accommodated in the above room. The panel room shall be air-conditioned. Further, the temperature of the room shall be monitored through substation automation system by providing necessary temperature transducers. The Switchyard panel room as detailed in section Substation Automation System is not required for GIS station.

16. ELECTRIC OVERHEAD CRANE:

16.1. One EOT Crane each for GIS hall of suitable capacity shall be provided for erection & maintenance of largest GIS component/assembly. The crane shall consist of all special requirements for erection & maintenance of GIS equipment.

16.2. The capacity of the crane shall be sized to lift the heaviest GIS switchgear component crane.

16.3. The Crane shall be used for the erection and maintenance of the GIS switchgear component and all plant installed in the GIS switchgear room. On completion of erection of the switchgear, the Contractor shall completely service the crane before the Taking Over Certificate is issued.
16.4. Crane hook approaches shall be of the minimum possible dimensions to ensure maximum coverage of the plant area.

16.5. The crane(s) shall be capable of lifting and accurately positioning all loads ranging from full crane rated capacity to at least 10% rated capacity.

16.6. The crane shall have minimum speeds under full load of:

   Speed
   (a) Hoisting  2 meters/minute
   (b) Cross Travel  10 meters/minute
   (c) Long Travel  20 meters/minute
   (d) Creep speed shall be of 25% of operating speed

16.7. The electric overhead cranes shall be provided with walkways, platforms. Guard hand rails shall be provided along the bridge rails and on the crab of EOT crane to facilitate cleaning/maintenance of the crane and to give access to the GIS room high bay lighting and ventilation duct and grilles.

16.8. The platform and walkways shall be designed to support any weight to be imposed upon them during crane overhaul.

16.9. An access platform shall be provided together with a guarded ladder on the crane to allow access to the bridge rails.

16.10. The crane shall be possible to be operated through the cable, through the pendant control and which shall be easily accessible from the floor of GIS building and through remote control device.

16.11. Contractor shall submit the capacity calculation of crane for GIS hall considering a factor of safety of 5.

   a) The crane for 220kV GIS/132kV GIS shall have capacity of minimum 5T safe working load & minimum height of crane have shall be 8.0 meters or as per actual requirement whichever is higher.

16.12. In case the GIS hall is to be extended, the scope of work also involves extension of EOT crane girders to facilitate movement of EOT crane in the extended portion of GIS hall.

16.13. The following tests may be EOT Crane

   1. The crane shall be tested at manufacturer work under full load and 25 percent overload of hoisting and cross transverse motions as a routine test.

   2. Further the following tests may be done at site after installation of the crane at site

      a. Check all the accessories for proper function
      b. No load test
      c. Load test as per site conditions

17. VENTILATION SYSTEM FOR GIS HALL

17.1. Each GIS Hall shall have an independent ventilation system. Each Ventilation system shall consist of two 100% capacity systems, one operating and one stand-by.

17.2. To ensure that the air being supplied to the GIS hall is free from dust particles, a minimum two stage dust filtration process shall be supplied. This shall consist of at least the following:
1. Pre Filters: To remove dust particles down to 10 micron in size with at least 95% efficiency.
2. Fine Filters: To remove dust particles down to 5 microns in size with at least 99% efficiency.

All the filters shall be panel type. Easy access should be available to the filters for replacement/cleaning.

The ventilation of the GIS hall shall be of a positive pressure type with minimum 4 air changes per hour. The pressure inside the GIS hall shall be maintained 5 mm of water above the atmospheric pressure. Fresh outdoor air shall be filtered before being blown into the GIS hall by the air fans to avoid dust accumulation on components present in the GIS hall. GIS hall shall be provided with motorized exhaust dampers with local control.

18. **SEISMIC DESIGN CRITERIA:**

18.1. The equipment shall be designed for operation in seismic zone for earthquake resistance. The seismic loads are due to the horizontal and vertical acceleration which may be assumed to act on concurrently. Seismic Qualification requirements shall be as per IEC 62271-207 for the design of equipment. The equipment along with its parts shall be strong enough and sufficiently well connected to resist total operating stresses resulting from the forces in normal operation, but in case of abnormal condition shall also resist with forces superimposed due to earthquakes. The copies of type test reports for similar rated equipment, if tested earlier, should be furnished. If the equipment has not been type tested earlier, Test Report/Analysis Report should be furnished.

18.2. To prevent the movement of GIS sub-assemblies i.e. various bay modules during the earthquake, suitable devices shall be provided for fixing the sub-assemblies to the foundation. The contractor shall supply necessary bolts for embedding in the concrete foundation. The fixing of GIS sub-assemblies to the foundation shall be designed to withstand the seismic events. It will also be ensured that the special devices as well as bolts shall not be over stressed. The details of the devices used and the calculations for establishing the adequacy shall be furnished by the supplier and shall be subject to the employer’s/consultant approval.

19. **DESIGN REVIEW**

19.1. Design reviews shall be conducted by Employer/consultant or an appointed consultant during the detailed Engineering of the GIS; however the entire responsibility of design shall be with the supplier.

19.2. Employer/consultant may also visit to the supplier’s works to inspect design, manufacturing and test facilities.

19.3. The design review will commence after placement of award with the successful contractor and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the GIS under the scope of this specification. Employer/consultant reserve the right to waive off the design review during detailed engineering.

19.4. The design review shall be conducted generally following the, “User Guide for the application of Gas Insulator Switchgear (GIS) rated voltage of 72.5kV and above” – CIGRE report No. 125 prepared by CIGRE Working Group 23.10.

19.5. The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric, insulation coordination and vibration etc. design to take into the account the uncertainties of his design and manufacturing processes.

19.6. The scope of such a design review shall at least include the following:
1. Dielectric Stress of Solid Insulation like Gas Barrier, support insulator etc.
3. Mechanical strength of enclosure, expansion joints etc.
4. Criteria for providing expansion joint.
5. Sealing system
6. Insulation coordination
7. Thermal stress and resulting increase in gas pressure during short circuit condition.
8. Earthing of enclosure w.r.t circulating current.
9. Seismic design, as per IEC 62271-207
11. Isolator and Earth switch.
12. Voltage transformer.
15. Bushing.
17. Corrosion protection.
18. Electrical and physical Interfaces with substation.
20. Inspection and test plan.
21. Transport and storage.
22. Maintainability.
23. Site Test.

19.7. Further, the manufacturer shall furnish the following information

a) Details regarding the loosely distributed metallic particles within the GIS encapsulation and calculations of critical field strength for specific particles of defined mass and geometry.

b) Study report of VFTO generated for GIS installation.

c) The methodology and all the equipment for electrical partial discharge (PD) detection, including that mentioned in the specification else-where.

d) The calculations and documents in support of the average intensity of electromagnetic field on the surface of the enclosure above during detailed engineering.

e) The detailed criteria/design regarding location of pressure relief devices/rupture diaphragms

f) Calculations to show that there is no Ferro resonance due to capacitance of GIS for the voltage transformers

g) Design calculation for simulated parameters for Seismic level as applicable

h) Insulation Coordination studies including studies to recommend for additional surge arrester

i) Calculation in support of touch & step voltages in all enclosures and earthing of complete GIS installation.

j) Measures to mitigate transient enclosure voltage by high frequency currents.

k) Calculation for providing bus duct supports.
20. **TYPE TESTS**

The offered GIS equipment shall conform to the type tests as per IEC-62271-203. Contractor shall submit type test reports for the following type tests & additional type tests.

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The test reports of the above type tests for GIS (including type test report on Circuit breaker, Disconnectors, Grounding switches, Current and Voltage transformers as per relevant IEC and type tests of SF6/Air & Oil bushing as per IEC 60137 shall be submitted for approval as per Section- GTR, Technical Specification.

21. **GENERAL**

21.1. **Painting of enclosure**: All enclosures shall be painted externally as per manufacturer’s painting procedure. The painting procedures as followed shall be submitted during detailed engineering.

21.2. **Heaters**: Wherever required, heaters shall be provided to prevent moisture condensation. Heaters are not allowed inside the main circuit.

21.3. **Identification & rating plate**

Each bay shall have a nameplate showing

a) A listing of the basic equipment (such as a breaker, Disconnectors grounding switches, current transformers, voltage transformers, and bushings etc).

b) A schematic diagram indicating their relative locations.

c) NEA Contract Number.

d) Each module will have its own Identification & rating plate. The rating plate marking for each individual equipment like Circuit breaker, Disconnectors Grounding switches, Current transformer, Voltage transformers, Surge arrester etc shall be as per their relevant IEC.
22. TRANSPORT OF EQUIPMENT TO SITE
The contractor shall be responsible for the loading, transport, handling and offloading of all equipment and materials from the place of manufacture or supply to site. The contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangements with the appropriate authorities as well as determining any transport restrictions and regulations imposed by the government and other local authorities. All transport packages containing critical units viz Circuit breakers and Voltage transformers shall be provided with sufficient number of electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory and must continue till the units reach site. The data of electronic impact recorders shall be downloaded at site and a soft copy of it shall be handed over to Engineer – in-charge. Further, contractor shall communicate the interpretation of the data within three weeks.

23. PACKING, STORAGE AND UNPACKING
23.1. All the equipment shall be carefully packed for transport by sea, rail and road in such a manner that it is protected against the climatic conditions and the variations in such conditions that will be encountered enroute from the manufacturer’s works to the site.
23.2. The SF6 metal clad equipment shall be shipped in the largest factory assembled units that the transport and loading limitations and handling facilities on site will allow to reduce the erection and installation work on site to a minimum.
23.3. Where possible all items of equipment or factory assembled units shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Should the units be considered too large for packing in crates, they shall be suitably lagged and protected to prevent damage to any part, particularly small projections, during transport and handling. Special lugs or protective supports shall be provided for lifting to prevent slings and other lifting equipment from causing damage. Each crate, container or shipping unit shall be marked clearly on the outside to show where the weight is bearing and the correct position for the slings.
23.4. Each individual piece to be shipped, whether crate, container or large unit, shall be marked with a notation of the part or parts contained therein.
23.5. Special precautions shall be taken to protect any parts containing electrical insulation against the ingress of moisture. This applies particularly to the metal clad equipment of which each gas section shall be sealed and pressurized prior to shipping. Either dry nitrogen/air or dry SF6 gas shall be used and the pressure shall be such as to ensure that, allowing for reasonable leakage, it will always be greater than the atmospheric pressure for all variations in ambient temperature and the atmospheric pressure encountered during shipment to site and calculating the pressure to which the sections shall be filled to ensure positive pressure at all times during shipment. The type of gas, the maximum pressure to which sections will be filled prior to shipment and the minimum allowable pressure during shipment shall be advised prior to dispatch.
23.6. All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided as part of the contract and shall remain the property of NEA. If considered necessary, blanking plates or other sealing devices shall be provided with facilities for measuring the gas pressure and recharging at any time during the transport period. Any seals, gaskets, ‘O’ rings, etc. that may be used as part of the arrangement for sealing off gas sections for shipment of site, shall not
be used in the final installation of the equipment at site. Identification serial numbers shall be stamped into the blanking plates, etc., and on the switchgear equipment to which they are fitted so that they can easily be identified and refitted should it ever be necessary to ship sections of the switchgear back to the manufacturer’s works for repair.

23.7. Valves and other gas couplings associated with the switchgear gas systems shall be adequately protected against damage from any bumps or physical blows. They shall also be capped to prevent ingress of dirt or moisture or damage to any coupling, pipes, threads or special fittings. Any explosion vents and other pressure relief devices, shall be suitably sealed and protected to prevent accidental exposure of the sealed sections during shipment to site.

23.8. For bus ducts involving male and female joints of the current carrying conductor, the same shall be transported in disassembled condition to avoid any damage during transit. All bright parts liable to rust shall receive a coat of anti rusting composition and shall be suitably protected.

23.9. The contractor will be able to use the available storage areas at site. The contractor shall ensure that during the period between arrival at site and erection, all materials and parts of the contract works are suitably stored in such approved manner as to prevent damage by weather, corrosion, insects, vermin or fungoral growth. The scope of providing the necessary protection, storing off the ground, as required etc. is included in the works to be performed by the contractor.

23.10. The equipment shall only be unpacked or removed from the containers immediately prior to being installed. They shall not be left lying unnecessarily in open crates or containers. Special precautions shall be taken when gas sections which have been sealed and pressurized for shipping are opened up to reduce the ingress of dirt and atmospheric moisture to a minimum. Whenever possible this shall only be done immediately prior to installation and if any section is to be left outside for any length of time after being opened, it shall be resealed and pressurized with either dry nitrogen/air or SF6 gas until required.

24. INSTALLATION OF GIS

24.1. Civil works of GIS Hall shall be completed in all respects for taking up the installation and it shall be ensured that all dust and dirt in the hall are removed. All openings (including Bus Duct) except entry door should be closed and proper sealed.

24.2. The installation area shall be secured against entry of unauthorized personnel. Only certified manufacturer’s engineer and supervisor shall supervise critical & important erection works. The help of local technicians can be taken only for material handling and non-critical erection works. Engineers and supervisors of the manufacturer shall submit authorization and competency certificate.

24.3. Assembly drawing for GIS erection for the section under progress shall be available and displayed in GIS hall at the time of work.

24.4. Proper power supply shall be ensured by installing DG Set of proper rating and frequency if required prior to commencement of erection work so that assembly work is not interrupted in the middle which is critical for GIS installation.

24.5. Working personnel shall clean their shoes or apply covers on shoes before entering the immediate working area. The working clothes of authorized personnel shall be made of non fluffy material.

24.6. GIS hall door shall have automatic close facility after entry of personnel to avoid dust and moisture entry. Walls and ceiling shall be in a condition so that neither dirt nor plaster might fall or rub off and formation of condensation water in ceiling shall be prevented under any circumstances.
24.7. Floor in the installation area shall have a firm surface and shall be kept dust free with a vacuum cleaner. Vacuum cleaning to be done at regular interval through out the day with separate team of persons assigned for cleaning work only.

24.8. Only T&P and consumables required for GIS erection shall be kept in GIS during erection.

24.9. In case of outdoor installation of GIS or of GIS components open gas compartments shall be protected from dust and moisture ingress (by tarpaulin covers etc)

24.10. Bus duct exit in the GIS hall wall shall be kept covered by suitable means until permanent cover is provided after installation of bus ducts.

24.11. A separate room shall be identified in consultation with NEA/consultant for carrying out repair works / small part assembly and the room shall be weather protected and lockable. All excess material (not required for immediate installation works) test equipment and tools and tackles to be stored separately from GIS hall in the separate room for rework.

24.12. All assembly work shall be done by qualified personnel only who are to be identified before starting of erection work.

24.13. Erection agency shall submit method statement and make available formats for checking during each stage of hall preparation, assembly process and final checks to be approved before start of erection. Method statement shall include record of shock / impact recorder at the time of unpacking. Shock recorder down loaded data and analysis shall be submitted before commencement of erection work. In case of violation of shock limits, expert form manufacturer shall visit and do the internal inspection before giving clearance for erection.

24.14. Cleaning is of utmost importance and hence before assembly, all the loose metal parts, subassemblies and all contact& sealing surfaces shall be cleaned before installation. Cleaning shall be carried out with specified cleaning agents of the manufacturer in no condition water is to be used except for external surfaces. Further, Prior to opening, gas compartment shall be thoroughly cleaned and vacuum cleaning of the installation area shall also be done specially the immediate vicinity of the flanges to be connected. Dust disturbance in the area to be avoided.

Also, before closing a flange connection clean the immediate vicinity and all accessible parts of the components shall be connected with a vacuum cleaner.

24.15. Once the transport covers are removed installation of flanges shall be done without any interruptions, if interruptions cannot be avoided open flanges are to be covered with clean plastic foil. Transport covers, O-rings and other packing material shall be taken out of GIS after immediately after removal.

24.16. O Rings shall be properly stored and taken out only before installation. O Rings are also to be cleaned before use with manufacturer authorized cleaning agent.

24.17. At all points of time during installation authorized personnel shall use disposable gloves to avoid contamination.

24.18. Cable termination work shall commence only after completion of GIS equipment as during GIS installation period laying and termination of cables interferes with the GIS erection work and affects cleanliness.

24.19. Approved Field Quality Plan shall be followed strictly during site work.

25. **ON SITE TESTING**

After the switchgear has been completely installed on site and filled with SF6 gas, the complete assembly shall be subjected to the site tests as per IEC – 62271-203 and with the test voltages specified below :-
25.1. The adequacy of number of UHF sensors and their location shall be verified as per recommendations of CIGRE task force TF 15/33.03.05 (Task force on Partial discharge detection system for GIS: Sensitivity verification for the UHF method and the acoustic method). In case during site testing additional UHF sensors are required, the same shall also be supplied and installed to complete the technical requirement.

25.2. Application of AC voltage equal to 1.2 times the service voltage in order to condition the GIS whilst at the same time permitting measurement of Partial discharge and detection of conductive particles by UHF method.

25.3. In case of a disruptive discharge in the gas as outlined in clause no: C.6.2.2 Procedure b) , annexure – C of IEC : 62271-203 , and a repeat test is performed due to failure during the AC voltage test , then the test shall be carried out at 1.2 times the service voltage .

The analysis of PD measured during High voltage test shall done very carefully and presence of PD measured by any sensor shall be attended and HV test shall be repeated after the rectification work. Calibration of PD sensors shall be completed before start of HV test to establish reference for detection of PD above 5 pc

25.4. Method statement/ procedure of on site high voltage testing and PD measurement shall be submitted by contractor in advance.

26. TESTING & MAINTENACE EQUIPMENT

All testing & maintenance equipment shall be offered, if specified as per relevant schedule of BPS.


The detector shall be portable, battery operated with built in battery charger, hand held type and having a minimum SF6 gas leakage sensitivity of 5gm/year. The sensor shall be connected through a flexible wand for easy accessibility to joints, seals and couplings in GIS equipment and provided with a protection filter. The equipment shall have on/off switch & suitable indicating lamps/LEDs, variable pitch audible signal for leakage indication, and a head phone jack. The equipment shall have automatic zeroing of background signals suitable for detecting SF6 gas leakage in charged switchyard. The test kit shall be compatible for EMI/EMC environment as per IEC 1000.

26.2. Gas filling and evacuating plant :

26.2.1. The plant necessary for filling and evacuating the SF6 gas in the switchgear shall be supplied to enable any maintenance work to be carried out. This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas. The capacity of the temporary storage facilities shall at least be sufficient for storing the maximum quantity of gas that could be removed from at least one phase of one complete bay(switchgear and associated equipment).

26.2.2. Where any item of the filling and evacuating plant is of such a weight that it cannot easily be carried by maintenance personnel, it shall be provided with lifting hooks for lifting and moving with the overhead cranes.

26.2.3. The minimum capacity of evacuation plant will be as under :

   Vacuum Pump: 60 M³/ Hour (Nominal suction pressure)
   Compressor: 15 M³/ Hour (Delivery)

26.2.4. The evacuation equipment shall be provided with all the necessary pipes, couplings, flexible tubes and valves for coupling up to the switchgear for filling or evacuating all the gases.
26.2.5. The gases compartments shall preferably be fitted with permanent non-return valves through which the gas is pumped into or evacuated from the compartments.

Details of the filling and evacuating plant that will be supplied, as well as the description of the filling and evacuating procedures shall be furnished.

26.3. **SF6 gas analyzer:**

The SF6 gas analyzer should be of portable type and instruments shall have following features:

a. In-built calibration facility.

b. Sensitivity of the equipment shall not be affected by any atmospheric conditions like dust, humidity, heat, wind etc.

c. Equipment shall work on zero gas loss principle i.e. gas should be pumped back to the compartment after measurement without any exposure to the atmosphere.

d. Equipment shall be supplied with suitable regulator which can be used to connect SF6 cylinder if required.

e. Following acidic/impurities products should be detected as per IEC 60480 and IEC 60376:
   
i) SF6 purity – Range: 0-100 % & Accuracy: +/- 0.5 %
   
ii) Dew point - Range : -60 to +20 deg C & Accuracy: +/- 0.5 deg C
   
iii) SO2 - Range : 0-150 ppm & Accuracy : +/- 2 %
   
iv) CF4 – Range : 0-60% vol & Accuracy : +/- 1 %
   
v) HF - Range : 0-200ppm & Accuracy : +/- 5 %

f. Instrument should work on AC source as well as on rechargeable battery

g. Input pressure: upto 10 bar

h. It should be housed in a robust IP67 case with wheels

26.3.1. **Portable Partial Discharge(PD) monitoring system**

26.3.2. The equipment shall be used for detecting different types of defects in Gas Insulated Stations (GIS) such as Particles, Loose shields and Partial Discharges as well as for detection of Partial discharges in other types of equipment such as Cable Joints, CTs and PTs.

26.3.3. It shall be capable for measuring PD in charged GIS environment as EHV which shall have bandwidth in order of 100 MHz–2GHz with possibility to select a wide range of intermediate bandwidths for best measurement results. The principle of operation shall be based on UHF principle of detection. The instrument should also be able to detect partial discharges in cable joints and terminations.

26.3.4. Detection and measurement of PD and bouncing particles shall be displayed on built in large LCD display and the measurement shall be stored in the instrument and further downloadable to a PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc. Software for display and diagnosis of PD signals and an expert software system for accurate interpretation of cause of PD shall also be supplied and installed by the contractor.

26.3.5. The equipment shall meet the following requirements

1. Measurement shall be possible in noisy environment.

2. Stable reading shall be possible in presence of vibrations within complex GIS assemblies, which can produce signals similar to PD.

3. Equipment should have necessary synchronizing circuits to obtain PD correlation with power cycle and power frequency.

4. The equipment shall be battery operated with built-in-battery charger. It shall also be suitable for 230V AC/50 Hz input.
5. Measurement shall be possible in the charged switchyard in the presence of EMI/EMC. Supplier should have supplied similar detector for GIS application to other utilities. Performance certificate and the list of users shall be supplied along with the offer.

6. Instrument shall be supplied with standard accessories i.e., re-locatable sensors with mounting arrangements, connecting cables (duly screened) to sensors, Lap-top PC, diagnostic and expert interpretation software, carrying case, rechargeable battery pack with charger suitable for 230V AC, 50Hz supply connecting cables (duly screened) to view in storage.

7. The function of software shall be covering the following:
   a) Data recording, storage and retrieval in computer
   b) Data base analysis
   c) Template analysis for easy location of fault inside the GIS
   d) Evaluation of PD measurement i.e, Amplitude, Phase Synchronization etc.
   e) Evaluation of bouncing/loose particles with flight time and estimation on size of particle.
   f) Expert software system for accurate interpretation of cause of PD.
   g) Report generation.

8. To prove the suitability in charged switchyard condition, practical demonstration shall be conducted before acceptance.

9. Supplier shall have “Adequate after sales service” facility.

10. Necessary training may be accorded to personnel to make use of the kit for locating PD sources inside the GIS

11. Instrument shall be robust and conform to relevant standard.

26.3.6. **Calibration:** The UHF Couplers have to be first calibrated as per CIGRE procedure TF 15/330305 as part of factory acceptance tests to guarantee detection sensitivity of 5pC or better. The GIS of same design shall be used as test specimen during the coupler calibration. The pulse injection level determined through above factory calibration tests shall only be used as reference for site sensitivity checks during commissioning of PDM system. The data sheet/frequency response characteristics shall be submitted for reference.

26.3.7. Pulse generator for UHF sensor sensitivity test shall also be supplied as a standard accessory.

### TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Parameter</th>
<th>220kV system</th>
<th>132kV system</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rated voltage kV (rms)</td>
<td>245</td>
<td>145</td>
</tr>
<tr>
<td>2.</td>
<td>Rated frequency (Hz)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>3.</td>
<td>No. of poles</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>Type of circuit breaker</td>
<td>SF6 insulated.</td>
<td>SF6 insulated.</td>
</tr>
<tr>
<td>5.</td>
<td>Rated continuous current (A) at an ambient temperature of 50°C</td>
<td>1600/2400/3000/4000 (as applicable)</td>
<td>800/1200/1600/2000 (as applicable)</td>
</tr>
<tr>
<td></td>
<td>Requirement</td>
<td>Value 1</td>
<td>Value 2</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------------------------------</td>
<td>----------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>6.</td>
<td>Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening conditions as specified.</td>
<td>40 kA (As applicable)</td>
<td>31.5 kA (As applicable)</td>
</tr>
<tr>
<td>7.</td>
<td>Symmetrical interrupting capability kA (rms) (As applicable)</td>
<td>40</td>
<td>31.5</td>
</tr>
<tr>
<td>8.</td>
<td>Rated short circuit making current kAp (As applicable)</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>9.</td>
<td>Short time current carrying capability for one second kA (rms) (As applicable)</td>
<td>50/40</td>
<td>80</td>
</tr>
<tr>
<td>10.</td>
<td>Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of U/√3 and 1.4 as per IEC-62271-100</td>
<td>As per IEC</td>
<td>As per IEC</td>
</tr>
<tr>
<td>11.</td>
<td>First pole to clear factor</td>
<td>1.3</td>
<td>As pr IEC</td>
</tr>
<tr>
<td>12.</td>
<td>Rated break time as IEC (ms)</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>13.</td>
<td>Total break time (ms)</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>14.</td>
<td>Total closing time (ms)</td>
<td>Not more than 200</td>
<td>Not more than 200</td>
</tr>
<tr>
<td>15.</td>
<td>Rated operating duty cycle</td>
<td>O-0.3s-CO-3 min-CO</td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td><strong>Rated insulation levels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full wave impulse withstand (1.2/50 µs) between line terminals and ground:</td>
<td>±1050 kVp</td>
<td>+650 kVp</td>
</tr>
<tr>
<td></td>
<td>Full wave impulse withstand (1.2/50 µs) Between terminals with circuit breaker open:</td>
<td>±1050 kVp</td>
<td>+750 kVp</td>
</tr>
<tr>
<td></td>
<td>Rated switching impulse withstand voltage (250/2500 µs) Dry &amp; wet.</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Rated switching impulse withstand voltage (250/2500 µs) Dry &amp; wet Between terminals with circuit breaker open:</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>One minute power frequency</td>
<td>460 kV rms.</td>
<td>275 kV rms.</td>
</tr>
<tr>
<td></td>
<td>withstand voltage between line terminals and ground</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td></td>
<td>One minute power frequency withstand voltage between terminals with circuit breaker open</td>
<td>530 kV rms.</td>
<td>315 kV rms</td>
</tr>
<tr>
<td>18.</td>
<td>Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 266 kV (Micro volts)</td>
<td>1000 µV</td>
<td>500µV</td>
</tr>
<tr>
<td>19.</td>
<td>Max. difference in the instants of closing/opening of contacts (ms) between poles</td>
<td>As per IEC</td>
<td>As per IEC</td>
</tr>
<tr>
<td>20.</td>
<td>Trip coil and closing coil voltage with variation as specified in Sec. GTR</td>
<td>220 V DC</td>
<td>220 V DC</td>
</tr>
<tr>
<td>21.</td>
<td>Rating of Auxiliary contacts</td>
<td>10A at 220 V DC</td>
<td>10A at 220 V DC</td>
</tr>
<tr>
<td>22.</td>
<td>Breaking capacity of Aux. Contacts less than 20 ms.</td>
<td>10A at 220 V DC</td>
<td>10A at 220 V DC</td>
</tr>
<tr>
<td>23.</td>
<td>System neutral earthing</td>
<td>Solidly Gound</td>
<td></td>
</tr>
</tbody>
</table>
# TECHNICAL PARAMETERS FOR DISCONNECTORS/ ISOLATORS

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Particulars</th>
<th>220 kV</th>
<th>132 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rated voltage (rms) Un</td>
<td>245 kV</td>
<td>145 kV</td>
</tr>
<tr>
<td>2.</td>
<td>Rated frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>3.</td>
<td>System earthing</td>
<td>Effectively earthed</td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>4.</td>
<td>Type</td>
<td>SF6 insulated</td>
<td>SF6 insulated</td>
</tr>
<tr>
<td>5.</td>
<td>Rated continuous current (A) at 50°C ambient temp. (as applicable)</td>
<td>1600/2400/3000/4000A</td>
<td>800/1200/1600/2000A</td>
</tr>
<tr>
<td>6.</td>
<td>Rated short time withstand current of isolator and earth switch (as applicable)</td>
<td>40 kA for 1 Sec.</td>
<td>31.5 kA for 1 second</td>
</tr>
<tr>
<td>7.</td>
<td>Rated dynamic short circuit withstand current of isolator and earth switch (As applicable)</td>
<td>1125/00 kA p.(As applicable)</td>
<td>80 kA p</td>
</tr>
<tr>
<td>8.</td>
<td>Rated insulation level:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>One minute power freq. Withstand voltage: To earth:</td>
<td>460 kV rms.</td>
<td>275 kV rms.</td>
</tr>
<tr>
<td></td>
<td>One minute power freq. Withstand voltage: Across isolating distance</td>
<td>530 kV rms.</td>
<td>315 kV rms.</td>
</tr>
<tr>
<td></td>
<td>1.2/50 micro sec. Lighting impulse withstand voltage (+ve or -ve polarity) To earth:</td>
<td>±1050 kVp</td>
<td>±650 kVp</td>
</tr>
<tr>
<td></td>
<td>1.2/50 micro sec. Lighting impulse withstand voltage</td>
<td>±1200 kVp</td>
<td>±750 kVp</td>
</tr>
<tr>
<td>(+ve or –ve polarity) : Across Isolating distance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry &amp; wet : between line terminals and ground:</td>
<td>N.A</td>
<td>N.A</td>
<td></td>
</tr>
<tr>
<td>Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry &amp; wet : between terminals with isolator open:</td>
<td>N.A</td>
<td>N.A</td>
<td></td>
</tr>
<tr>
<td>9. Mechanical Endurance clause as per IEC</td>
<td>M2</td>
<td>M1</td>
<td></td>
</tr>
<tr>
<td>10. No. of spare auxiliary contacts on each isolator</td>
<td>4 NO and 4 NC</td>
<td>4 NO and 4 NC</td>
<td></td>
</tr>
<tr>
<td>11. No. of spare auxiliary contacts on each earthing switch</td>
<td>4 NO and 4 NC</td>
<td>4 NO and 4 NC</td>
<td></td>
</tr>
</tbody>
</table>
### TECHNICAL PARAMETERS FOR CURRENT TRANSFORMERS

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Particular</th>
<th>220 kV</th>
<th>132kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rated voltage Un</td>
<td>245 kV (rms)</td>
<td>145 kV (rms)</td>
</tr>
<tr>
<td>2.</td>
<td>Rated frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>3.</td>
<td>System neutral earthing</td>
<td>Effectively Ear...</td>
<td>Effectively Ear...</td>
</tr>
<tr>
<td>4.</td>
<td>Rated short time thermal current for 1 second (as applicable)</td>
<td>40 kA</td>
<td>31.5 kA</td>
</tr>
<tr>
<td>5.</td>
<td>Rated dynamic current</td>
<td>100 kA</td>
<td>78.75kA</td>
</tr>
<tr>
<td>6.</td>
<td>Rated insulation levels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

i. 1.2/50 micro second impulse voltage ±1050 kVp ±650 kVp

ii. one minute power frequency withstand voltage 460 kV (rms) 275 kV (rms)

7. Maximum temperature rise over an ambient temperature of 40°C. As per IEC 60044-1 As per IEC 60044-1

8. Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz 1000 μV 500μV

9. One minute power frequency withstand voltage between sec. Terminal & earth 3 kV (rms) 3 kV (rms)

10. Partial discharge level 5 pico coulombs 5 pico coulombs

### TABLE-3A

**REQUIREMENTS FOR 220 kV CURRENT TRANSFORMER**

<table>
<thead>
<tr>
<th>Core no.</th>
<th>Application</th>
<th>Curren t ratio</th>
<th>Output Burden (VA)</th>
<th>Accuracy Class as Per IEC:</th>
<th>Min. Knee pt. Voltage Vk</th>
<th>Max. CT Sec. Wdg. Resistance (ohm)</th>
<th>Max. Excitation current at Vk (in mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>protection</td>
<td>1600-800/1</td>
<td>-</td>
<td>-</td>
<td>1600/800</td>
<td>8/4</td>
<td>25 on 1600/1tap. 50 on 800/1tap.</td>
</tr>
<tr>
<td>2</td>
<td>protection</td>
<td>1600-800/1</td>
<td>-</td>
<td>-</td>
<td>1600/800</td>
<td>8/4</td>
<td>25 on 1600/1tap. 50 on 800/1tap.</td>
</tr>
<tr>
<td>3</td>
<td>Metering</td>
<td>1600-800/1</td>
<td>20</td>
<td>0.2S</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>protection</td>
<td>1600-800/1</td>
<td>-</td>
<td>-</td>
<td>1600/800</td>
<td>8/4</td>
<td>25 on 1600/1tap. 50 on 800/1tap.</td>
</tr>
<tr>
<td>5</td>
<td>protection</td>
<td>1600-800/1</td>
<td>-</td>
<td>-</td>
<td>1600/800</td>
<td>8/4</td>
<td>25 on 1600/1tap. 50 on 800/1tap.</td>
</tr>
</tbody>
</table>

All protection Cores shall be of accuracy class TPS as per IEC:60044-6. However, if a
higher accuracy class CT is required for protection, the same shall be provided

<table>
<thead>
<tr>
<th>Core no.</th>
<th>Application</th>
<th>Current ratio</th>
<th>Output Burden (VA)</th>
<th>Accuracy Class as Per IEC: 44-1</th>
<th>Min. Knee pt. Voltage Vk</th>
<th>Max. CT Sec. Wdg. Resistance (ohm)</th>
<th>Max. Excitation current at Vk (in mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>protection</td>
<td>2400-1600/1</td>
<td>-</td>
<td>2400/1600</td>
<td>12/8</td>
<td>16.67 on 2400/1tap 25 on 1600/1tap.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>protection</td>
<td>2400-1600/1</td>
<td>-</td>
<td>2400/1600</td>
<td>12/8</td>
<td>16.67 on 2400/1tap 25 on 1600/1tap.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Metering</td>
<td>2400-1600/1</td>
<td>20</td>
<td>0.2S</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>protection</td>
<td>2400-1600/1</td>
<td>-</td>
<td>2400/1600</td>
<td>12/8</td>
<td>16.67 on 2400/1tap 25 on 1600/1tap.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>protection</td>
<td>2400-1600/1</td>
<td>-</td>
<td>2400/1600</td>
<td>12/8</td>
<td>16.67 on 2400/1tap 25 on 1600/1tap.</td>
<td></td>
</tr>
</tbody>
</table>

All protection Cores shall be of accuracy class TPS as per IEC:60044-6. However, if a higher accuracy class CT is required for protection, the same shall be provided

**TABLE-3B**

**REQUIREMENTS FOR 132 kV CURRENT TRANSFORMER**

<table>
<thead>
<tr>
<th>Core no.</th>
<th>Application</th>
<th>Current ratio</th>
<th>Output Burden (VA)</th>
<th>Accuracy Class as Per IEC: 44-1</th>
<th>Min. Knee pt. Voltage Vk</th>
<th>Max. CT Sec. Wdg. Resistance (ohm)</th>
<th>Max. Excitation current at Vk (in mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>protection</td>
<td>800-400/1</td>
<td>-</td>
<td>800/400</td>
<td>8/4</td>
<td>25 on 800/1 50 on 400/1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>protection</td>
<td>800-400/1</td>
<td>-</td>
<td>800/400</td>
<td>8/4</td>
<td>25 on 800/1 50 on 400/1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Metering</td>
<td>800-400/1</td>
<td>20</td>
<td>0.2S</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>protection</td>
<td>800-400/1</td>
<td>-</td>
<td>800/400</td>
<td>8/4</td>
<td>25 on 800/1 50 on 400/1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>protection</td>
<td>800-400/1</td>
<td>-</td>
<td>800/400</td>
<td>8/4</td>
<td>25 on 800/1 50 on 400/1</td>
<td></td>
</tr>
<tr>
<td>Core no.</td>
<td>Application</td>
<td>Current Ratio</td>
<td>Output Burden (VA)</td>
<td>Accuracy class as per IEC: 60044-1</td>
<td>Min knee point voltage VK</td>
<td>Max. CT sec. Wdg. resistance (ohms)</td>
<td>Max. Excitation current at VK (in mA)</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>---------------</td>
<td>--------------------</td>
<td>-----------------------------------</td>
<td>--------------------------</td>
<td>--------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>protection</td>
<td>4000-2400-1600-1</td>
<td>-</td>
<td>PS</td>
<td>4000-2400-1600-1</td>
<td>20/12</td>
<td>10 on 4000/1 16.67 on 2400/1 25 on 1600/1</td>
</tr>
<tr>
<td>2</td>
<td>protection</td>
<td>4000-2400-1600-1</td>
<td>-</td>
<td>PS</td>
<td>4000-2400-1600-1</td>
<td>20/12</td>
<td>10 on 4000/1 16.67 on 2400/1 25 on 1600/1</td>
</tr>
<tr>
<td>3</td>
<td>Metering</td>
<td>4000-2400-1600-1</td>
<td>20</td>
<td>0.2S</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>protection</td>
<td>4000-2400-1600-1</td>
<td>-</td>
<td>PS</td>
<td>4000-2400-1600-1</td>
<td>20/12</td>
<td>10 on 4000/1 16.67 on 2400/1 25 on 1600/1</td>
</tr>
<tr>
<td>5</td>
<td>protection</td>
<td>4000-2400-1600-1</td>
<td>-</td>
<td>PS</td>
<td>4000-2400-1600-1</td>
<td>20/12</td>
<td>10 on 4000/1 16.67 on 2400/1 25 on 1600/1</td>
</tr>
</tbody>
</table>

All protection Cores shall be of accuracy class TPS as per IEC:60044-6. However, if a higher accuracy class CT is required for protection, the same shall be provided.

**Table- 3C**

**REQUIREMENTS FOR 245 kV CURRENT TRANSFORMER**

(for Bus Coupler bay)
All protection Cores shall be of accuracy class TPS as per IEC:60044-6. However, if a higher accuracy class CT is required for protection, the same shall be provided.

**TABLE – 3D**

REQUIREMENTS FOR 145 kV CURRENT TRANSFORMER

(For Bus coupler bay)

<table>
<thead>
<tr>
<th>Core no.</th>
<th>Application</th>
<th>Current Ratio</th>
<th>Output Burden (VA)</th>
<th>Accuracy class as per IEC:60044-1</th>
<th>Min knee point voltage VK</th>
<th>Max. CT sec. Wdg resistance (ohms)</th>
<th>Max. Excitation current at VK (in mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>protection</td>
<td>2000-800/1</td>
<td>-</td>
<td>PS</td>
<td>2000-800/1</td>
<td>20/8</td>
<td>10 on 2000/1 25 on 800/1</td>
</tr>
<tr>
<td>2</td>
<td>protection</td>
<td>2000-800/1</td>
<td>-</td>
<td>PS</td>
<td>2000-800/1</td>
<td>20/8</td>
<td>10 on 2000/1 25 on 800/1</td>
</tr>
<tr>
<td>3</td>
<td>Metering</td>
<td>2000-800/1</td>
<td>20</td>
<td>0.2S</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>protection</td>
<td>2000-800/1</td>
<td>-</td>
<td>PS</td>
<td>2000-800/1</td>
<td>20/8</td>
<td>10 on 2000/1 25 on 800/1</td>
</tr>
<tr>
<td>5</td>
<td>protection</td>
<td>2000-800/1</td>
<td>-</td>
<td>PS</td>
<td>2000-800/1</td>
<td>20/8</td>
<td>10 on 2000/1 25 on 800/1</td>
</tr>
</tbody>
</table>

All protection Cores shall be of accuracy class TPS as per IEC:60044-6. However, if a higher accuracy class CT is required for protection, the same shall be provided.
### TECHNICAL PARAMETERS FOR VOLTAGE TRANSFORMERS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particular</th>
<th>220 kV</th>
<th>132 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated system voltage (Un)</td>
<td>245 kV (rms)</td>
<td>145 kV (rms)</td>
</tr>
<tr>
<td>2</td>
<td>Rated frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>3</td>
<td>System neutral earthing</td>
<td>Effectively earthed</td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>4</td>
<td>System fault level</td>
<td>50/40 kA (As applicable) for 1 Second.</td>
<td>31.5 kA</td>
</tr>
<tr>
<td>5</td>
<td>Rated insulation levels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>1.2/50 micro second impulse voltage</td>
<td>±1050 kVp</td>
<td>±650 kVp</td>
</tr>
<tr>
<td>ii.</td>
<td>one minute power frequency withstand voltage</td>
<td>460 kV (rms)</td>
<td>275 kV (rms)</td>
</tr>
<tr>
<td>iii.</td>
<td>250/2500 micro second switching impulse voltage (dry &amp; wet)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>One minute power frequency withstand voltage</td>
<td>3 kV (rms)</td>
<td>3 kV (rms)</td>
</tr>
<tr>
<td>7</td>
<td>Radio interference voltage at 1.1 Un/\sqrt{3} and frequency range 0.5 to 2 MHz</td>
<td>1000 µV</td>
<td>500 µV</td>
</tr>
<tr>
<td>8</td>
<td>Rated total thermal burden</td>
<td>400 VA</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Partial discharge level</td>
<td>10 Pico coulombs.</td>
<td>10 pico coulombs</td>
</tr>
</tbody>
</table>
TABLE -4A
REQUIREMENT OF VOLTAGE TRANSFORMERS

<table>
<thead>
<tr>
<th>S. No.</th>
<th>PARTICULARS</th>
<th>220 kV</th>
<th>132 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated primary voltage</td>
<td>220/√3 kV</td>
<td>132/√3 kV</td>
</tr>
<tr>
<td>2</td>
<td>Type</td>
<td>Electromagnetic</td>
<td>Electromagnetic</td>
</tr>
<tr>
<td>3</td>
<td>No. of secondaries</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Rated voltage factor</td>
<td>1.2 continuous</td>
<td>1.2 continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 for 30 seconds</td>
<td>1.5 for 30 seconds</td>
</tr>
<tr>
<td>5</td>
<td>Phase angle error</td>
<td>±10 minutes (for metering core)</td>
<td>±10 minutes (for metering core)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sec I</td>
<td>Sec II</td>
</tr>
<tr>
<td></td>
<td>Rated secondary voltage (V)</td>
<td>110/√3</td>
<td>110/√3</td>
</tr>
<tr>
<td>6</td>
<td>Application</td>
<td>Protection</td>
<td>Protection</td>
</tr>
<tr>
<td>7</td>
<td>Accuracy</td>
<td>3P</td>
<td>3P</td>
</tr>
<tr>
<td>8</td>
<td>Output burden (VA) (minimum)</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>
## TECHNICAL PARAMETERS OF GIS SURGE ARRESTER

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>220 kV</th>
<th>132 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated system voltage</td>
<td>245 kV</td>
<td>132 kV</td>
</tr>
<tr>
<td>2</td>
<td>System neutral earthing</td>
<td>Effectively earthed</td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>3</td>
<td>Rated arrestor voltage</td>
<td>216 kV</td>
<td>120 kV</td>
</tr>
<tr>
<td>4</td>
<td>Nominal discharge current</td>
<td>10 kA of 8/20 µs wave</td>
<td>10 kA of 8/20 µs wave</td>
</tr>
<tr>
<td>5</td>
<td>Rated frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>6</td>
<td>Minimum discharge capability voltage corresponding to minimum discharge characteristics</td>
<td>5 KJ/kV (referred to rated arrestor)</td>
<td>5 KJ/kV (referred to rated arrestor)</td>
</tr>
<tr>
<td>7</td>
<td>Continuous operating voltage at 50°C</td>
<td>168 kV</td>
<td>102 kV</td>
</tr>
<tr>
<td>8</td>
<td>Min. switching surge residual voltage</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. switching surge residual voltage</td>
<td>500 kVp</td>
<td>280kVp</td>
</tr>
<tr>
<td>9</td>
<td>Max. residual voltage at 5 kA</td>
<td>560 kVp</td>
<td>310kVp</td>
</tr>
<tr>
<td>11</td>
<td>Max. residual voltage at 10 kA nominal discharge current</td>
<td>600 kVp</td>
<td>330 kVp</td>
</tr>
<tr>
<td>12</td>
<td>Max. residual voltage at 20 kA nominal discharge current</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Steep fronted wave residual voltage</td>
<td>650kVp</td>
<td>330 kVp</td>
</tr>
<tr>
<td>14</td>
<td>Long duration discharge class</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>High current short duration test value (4/10 micro second wave)</td>
<td>100 kAp</td>
<td>100 kAp</td>
</tr>
<tr>
<td>16</td>
<td>Current for pressure relief test</td>
<td>50kA/50kA (as applicable)</td>
<td>31.5 kA</td>
</tr>
<tr>
<td>17</td>
<td>Prospective symmetrical fault current</td>
<td>40 kA rms for 0.2 Sec</td>
<td>As per IEC</td>
</tr>
<tr>
<td>18</td>
<td>Pressure relief class:</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>19</td>
<td>RIV at 1.1 U_n/√3 kV rms(micro volts)</td>
<td>Less than 500</td>
<td>Less than 500</td>
</tr>
<tr>
<td>20</td>
<td>Partial discharge at 1.05 COV (pC)</td>
<td>Not more than 5</td>
<td>Not more than 5</td>
</tr>
<tr>
<td>21</td>
<td>Reference ambient temp.</td>
<td>50 °C</td>
<td>50 °C</td>
</tr>
</tbody>
</table>
## TECHNICAL PARAMETERS FOR SF6/AIR BUSHING

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particular</th>
<th>220 kV</th>
<th>132kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated Voltage (kV)</td>
<td>245 kV (rms)</td>
<td>145 kV (rms)</td>
</tr>
<tr>
<td>2</td>
<td>Rated Current (Amp)</td>
<td>2400/1600</td>
<td>800/1200</td>
</tr>
<tr>
<td>3</td>
<td>1.2/50 micro second impulse voltage (Lightning impulse withstand voltage)</td>
<td>1050 kVp</td>
<td>630 kVp</td>
</tr>
<tr>
<td>4</td>
<td>250/2500 micro second switching impulse voltage</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>One minute power frequency withstand voltage</td>
<td></td>
<td>275 kV (rms)</td>
</tr>
<tr>
<td>6</td>
<td>Minimum total Creepage distance in mm</td>
<td>6125</td>
<td>3625</td>
</tr>
<tr>
<td>7</td>
<td>Minimum Cantilever strength (kN)</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>
CHAPTER 22 :- 33KV & 11KV INDOOR SWITCHGEAR (GIS TYPE)

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1.00 GENERAL

This specification covers the design, manufacture, assembly, testing at manufacture’s works before dispatch and delivery of metal clad partitioned, SF6 gas insulated, switchboard panel confirming to IEC-62271-200. The switchboard panels for line bays, transformer bays, bus coupler/Bus-section bays, etc. shall be fitted with Vaccume circuit breakers, three position disconnecting and earthing switches, voltage transformers, current transformer, metering instruments, protection relays, cable terminal ends for incoming & outgoing cable feeders etc. as per foregoing specification.

2.00 REFERENCE STANDARDS

2.01 The metal-enclosed gas-insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the relevant standards, specification and codes of practices, referred to herein & in Section GTR, and shall be the latest editions including all applicable official amendments and revisions as on the date of opening of bid. In case of conflict between this specification and those (IS Codes, Standards etc.), the former shall prevail. In addition to relevant standards specified in Section-GTR, following standards shall also be applicable:

<table>
<thead>
<tr>
<th>IEC 62271-200</th>
<th>Gas insulated metal-enclosed switchgear for rated voltage above 1kV and up to and including 52 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 62271-102</td>
<td>A.C. disconnectors (isolators) and Earthing switches for voltages above 1000 V</td>
</tr>
<tr>
<td>IEC 62271-207</td>
<td>Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV</td>
</tr>
<tr>
<td>IEC 60376</td>
<td>New Sulphur hexafluoride</td>
</tr>
<tr>
<td>IEC 62271-200</td>
<td>High voltage metal enclosed switchgear &amp; control gear Circuit breakers</td>
</tr>
<tr>
<td>IEC 60044-1</td>
<td>Current Transformers</td>
</tr>
<tr>
<td>IEC 60044-2</td>
<td>Voltage Transformers</td>
</tr>
<tr>
<td>IEC 62271-209</td>
<td>Cable connections for gas-insulated switchgear</td>
</tr>
</tbody>
</table>

2.02 The components and devices which are not covered by the above standards shall conform to, and comply with, the applicable standards, rules, codes and regulations of the internationally recognized standardizing bodies and professional societies as may be approved by the Employer and the manufacturer shall list all such applicable standards, codes etc.

2.03 Equipment conforming to any other internationally accepted standards, will also be considered if they ensure performance and constructional features equivalent or superior to the standards listed above.

3.00 EQUIPMENT SPECIFICATION

3.01 Switchgear Panel

a) Gas insulated Metal clad switchgear shall be complete with all the accessories for efficient and trouble free operation. The equipment offered shall be safe, reliable and compact to install. The workmanship shall be high order. The circuit breaker, switches and protective
device etc shall be latest design so as to ensure rapid and efficient interruption of fault current low arc energy, small arcing time and freedom from fire hazards.

b) The GIS shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric stress and insulation coordination etc. shall be maintained during design, selection of raw material, manufacturing process etc. so that the GIS provides long life with least maintenance.

c) The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.

d) The switchgear panel shall be free standing, floor mounted, fully compartmentalized, metal enclosed construction complying requirements of IEC 62271-200. Each circuit shall have a separate vertical panel with required compartments for circuit breaker, cable termination, main bus-bars and auxiliary control devices.

e) The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of it's constituent live parts.

f) The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The Service Class Continuity of Switchgears shall be LSC 2B-PM (as per IEC 622771-200).

g) All necessary equipment required for Gas handling at site (if any), shall be arranged by the supplier at their own cost.

h) All louvers (if provided), shall have very fine brass or GI mesh screen. Tight fitting gourmet / gaskets are to be provided at all openings in relay compartment. Relays shall be fully flush mounted on the switchgear panels at a suitable height from operator point of view.

i) Switchgear shall have an Internal Arc Classification of IAC-A-FLR 25 KA, 1 sec. The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Gas Pressure relief device/Explosion Vent/Pressure relief duct shall be provided for each SF6 gas compartment, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of it's spreading to other compartments and panels. The pressure relief device/Explosion Vent/Pressure relief duct shall not however reduce the degree of protection of panels under normal working conditions.

j) The switchgear shall be cooled by natural air flow.

k) Total height of the switchgear panels shall be finalized during detail engineering in line with building design. The height of switches, pushbuttons and other hand operated devices shall not exceed 1800 mm and shall not be generally less than 700 mm.

l) Suitable interlock & Indications shall be provided to prevent opening of any HT compartment doors, in case the incoming HT supply is ON.
m) Suitable base frames made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and leveled when the flooring is being done, welding of base frame to the insert plates shall be in Bidder’s scope. The bidder may offer panels with built in base frame ready for dispatch and suitable for installation on indoor cable trenches.

n) The switch board shall have the facility for extension on both sides. o) SF6 gas leakage rate should not exceed 0.5% per annum.

p) Thermostatically controlled space heater with common MCB shall be provided for various compartments.

3.02 Circuit Breakers (VCB Type)

a) The circuit breakers shall be of Vacuum type. It shall comprise of three single pole interrupting units or 3-pole interrupting unit, operated through a common shaft by a sturdy operating mechanism.

b) Circuit breaker shall be re-strike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. Anti-pumping features shall be provided for each breaker. An arrangement of two breakers in parallel to meet a specified current rating shall not be acceptable.

c) Circuit breaker shall be provided with two trip coils.

d) Suitable indicators shall be provided on the front of panel to indicate OPEN / CLOSED conditions of the circuit breaker, and CHARGED / DISCHARGED conditions of the closing spring, SF6 gas density monitor for all gas compartments.

e) The rated control supply voltage shall be as mentioned elsewhere under Technical parameters. The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 85-110% of the rated voltage. The trip coil shall operate satisfactorily under all operating conditions of the circuit breaker upto its rated short circuit breaking current at all values of control supply voltage between 70-110% of the rated voltage. The trip coil shall be so designed that it does not get energized when its healthiness is monitored by indicating lamps and trip coil supervision relay.

f) The time taken for charging of closing spring shall not exceed 60 seconds. The spring charging shall take place automatically preferably after a closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation. As long as power supply is available to the charging motor, a continuous sequence of closing and opening operations shall be possible. Spring charging motors shall be capable of starting and charging the closing spring twice in quick succession without exceeding acceptable winding temperature when the control supply voltage is anywhere between 85-
110% of rated voltage. The initial temperature shall be as prevalent in the switchgear panel during full load operation with 40 deg. C ambient air temperature. The motor shall be provided with Over load protection.

j) Motor windings shall be provided with class E insulation or better. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in a hot, humid and tropical climate.

3.03 Disconnecting & Earthing Switches

a) Each Switchgear panel shall be provided with three (3) position disconnecting-cum-earthing switch of required rating.

b) It shall be possible to control these switches from front of the panel & remotely from SCADA/SAS through IED.

c) Necessary indication shall be provided on the front of the panel for Close/Open status of the three position switches.

3.04 Control and Interlocks

a) The circuit breaker shall normally be controlled remotely from SAS/SCADA system through closing and trip coils. However, it shall also be designed to control locally from Indoor Switchgear panel. Suitable mimic on Panel shall be provided.

b) Facilities shall be provided for mechanical tripping of the breaker in an emergency. Facility shall also be provided for manual charging of the stored energy mechanism for a complete duty cycle.

c) Necessary mechanical & Electrical interlocks shall be provided between CB, Isolator & Earth switches for failsafe operation.

d) Each CB, Isolator & earth switch shall have 2 NO + 2 NC Auxiliary spare contacts for future use by owner.

3.05 Busbars and Insulators

a) Busbar shall be of Copper of adequate size and bus bar size calculation / supporting type test report shall be submitted for approval. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit currents.

b) Busbar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators.

c) Bus bar cross-section shall be uniform throughout the length of switchgear board. Bus bars shall be in SF6 gas insulated compartment.
d) Busbar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. In case of organic insulator partial discharge shall be limited to 100pico coulomb at rated Voltage X 1.1/√3.

e) All busbars shall have suitable phase identification. Bus switching scheme shall be as per Single Line diagram attached with bidding documents.

f) The temperature of the busbars and all other equipment, when carrying the rated current continuously shall be limited as per the stipulations of relevant Standards, duly considering the specified ambient temperature (40 deg. C).

3.06 Earthing and Earthing Devices

a) The grounding system for GIS shall be designed and provided as per IEEE-80-2000 and CIGRE- 44 to protect operating staff against any hazardous touch voltages and electromagnetic interferences.

b) A copper / galvanized steel earthing bus shall be provided at the bottom and shall extend throughout the length of each switch board. It shall be bolted/ welded to the framework of each panel and each breaker earthing contact bar. The earth bus shall have sufficient cross section to carry the momentary short-circuit and short time fault currents to earth without exceeding the allowable temperature rise.

c) Suitable arrangement shall be provided at each end of the earth bus for bolting to station earthing grid. All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.

d) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical continuity of the whole switchgear enclosure frame work and the truck shall be maintained even after painting.

e) All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering shall not be acceptable. Looping of earth connections which would result in loss of earth connection to other devices, when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths of earth bus is acceptable.

f) VT and CT secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit may be removed without disturbing the earthing of other circuits.

g) The panel shall have Voltage Presence Indicator (VPI) to warn the operator against earthing of live connections.

h) All hinged doors shall be earthed through flexible earthing braid.

3.07 Instrument Transformers
a) All current transformers shall preferably be ring type where as voltage transformers (PT) shall be cast resin insulated type.

b) Instrument transformers shall be suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 40 deg. C. The class of insulation shall be E or better.

c) All instrument transformers shall withstand the power frequency and impulse test voltage specified for the switchgear assembly. The current transformer shall further have the dynamic and short time ratings at least equal to those specified for the associated switchgear and shall safely withstand the thermal and mechanical stress produced by maximum fault currents specified when mounted inside the switchgear for circuit breaker modules.

d) The parameters of instrument transformers specified in this specification are indicative and shall be finalized by the Employer during detailed engineering, considering the actual burden of various relays and other devices finally selected. In case the Bidder finds that the specified ratings are not adequate for the relays and other devices offered by him, he shall offer instrument transformer of adequate ratings without any cost implication.

e) All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.

f) All voltage transformer’s secondary circuits shall have suitable HRC/MCB protective devices.

3.08 **Numerical Protection Relays (IEDs)**

3.08.01 Indoor switchgear panels shall have communicable numerical protection relays (IEDs) complying with IEC-61850 on all feeders which shall be networked on Ethernet to communicate with substation SAS/SCADA system on IEC-61850. These IEDs shall also be used for control & monitoring the switchgear from SAS. In addition to status of devices (CBs/Isolators/Earth Switches) and equipment alarms, Metering data shall also be made available to SAS/SCADA station from protection IEDs. Further, multifunction meters with Modbus protocol are also envisaged, which will be connected in daisy-chain-link to communicate to station SAS. Modbus to IEC 61850 converter shall be provided for integration with SAS.

The Bidder’s scope shall include the followings:

a) Communicable Numerical Protection Relays (with IEC 61850) in each of the feeders & Bus-section/Bus coupler

b) IED’s / Numerical Relays shall have digital display, Single line diagram (SLD) display to facilitate settings, relay operations and to view measurement, event and alarm etc.

c) Relays shall have built in Local/Remote Selector Switch.

d) Cat5e Ethernet cable for connection of Numerical Relays (IEDs) to Ethernet switches and Optical cable between Ethernet switch (for indoor switch gear IEDs) and ring/ redundant network of Substation LAN switch shall be used.
e) Required number of Ethernet switches mounted in Indoor Switchgear panels for communication with IEDs on IEC 61850 protocol.
f) The SAS/SCADA system has been envisaged as part of main substation. Bidder shall facilitate in successful Integration of Numerical Relays to the SAS/SCADA system through Ethernet switches.

3.08.02 All Numerical relays shall be of proven design for the application satisfying requirements specified elsewhere and shall be subject to Employer’s approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity for the intended application.

3.08.03 All numerical relays shall be rated for control supply voltage as mentioned elsewhere under system parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Heavy duty binary output contacts of IEDs to be used for breaker close and trip commands shall be so rated as to be used directly in the closing and tripping circuits of breaker without the need of any interposing / master trip relays.

3.08.04 Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal-operation due to stray voltages and typically shall be more than 70% of the rated control supply voltage.

3.08.05 All IEDs shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts as per approved scheme. These I/O points shall be used for wiring of status of devices (CB/Isolator/Earth switch) and equipment alarms etc.

3.08.06 Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.

3.08.07 Relays shall have event recording feature with time stamping. Event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.

3.08.08 All Numerical relays shall have features for electrical measurements including voltage, current, power (active & reactive), frequency, power factor etc.

3.08.09 All numerical relays shall have provision of both current (CT) and voltage (VT) inputs as required for protection & measurement purposes using protection cores.

3.08.10 All numerical relays shall have built-in key pad / keys to allow relay setting from relay front. Resetting of relay shall be possible from remote SCADA.

3.08.11 Relays shall have suitable output contact for circuit breaker failure protection (LBB) logic.

3.08.12 Relays shall have self diagnostic feature with continuous self check for power failure, program routines, memory and main CPU failures and a separate output contact for indication of any failure.

3.08.13 Contractor shall submit applicable Type Test reports for Numerical relays as per IEC including report for IEC 61850 protocol from accredited lab.
3.09 Control & Protection System

All numerical relays shall communicate to station SCADA / SAS on IEC-61850 communication protocol. It is envisaged that these protection IEDs shall be used for CB control & monitoring of bay equipments.

3.09.01 Numerical Transformer Protection Relay

a) The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protection elements.

b) The over current element should have the minimum setting adjustable between 20-200% of CT secondary rated current and high set setting 500-2000%.

c) The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current (IDMT) and high set 100-1000%.

d) The relay shall have selectable directional & non-directional feature

e) For transformers of rating 5MVA and above, definite time delayed Stand by earth fault protection shall be provided having a pick up setting range of 10% to 40% with a timer delay of 0.3 sec to 3 sec.

f) The relay shall allow higher setting during transformer charging (inrush) and lower setting during normal operating condition.

g) Transformer troubles like Buchholz, Winding temperature, Oil temperature & Pressure Relief Device trips etc. (as applicable) shall be wired independently to separate binary inputs of the relay and shall be configured to issue trip command to the breaker. Similarly alarm points shall be wired separately to binary inputs of the relay.

h) Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

3.09.02 Numerical Line Protection Relay

a) The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protection elements.

b) The over current element should have the minimum setting adjustable between 20-200% of CT secondary rated current.

c) The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current.

d) The relay shall have selectable directional & non-directional feature

e) Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

3.09.03 Numerical Bus Coupler/Bus-Section Protection Relay
a) The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protection elements.

b) The over current element should have the minimum setting adjustable between 20-200% of CT secondary rated current.

c) The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current.

d) No bus volt signal shall be configured in the relay for use in control logics and other Protections and Control functions in the Relays.

e) Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

3.09.04 Other Control and Protections features

a) Control of breakers, three position Isolators & Earth switches shall be carried out from the station HMI of SAS/SCADA system through the LAN and the numerical relays.

b) The station HMI shall have a graphical dynamic Plant Key Single Line Diagram to view the complete system status. This shall include the status of the switchgears, measurement values, operation counters, graphical alarm representation, etc. Spontaneous changes of a state, typically opening of a circuit breaker from a protection, shall have a specific colour code. All the Breakers with the status shall be clearly displayed along with values of currents, voltages, frequency, active and reactive powers etc.

c) Schematics requiring auxiliary relays / timers for protection function shall be part of numerical relay. Timer functions shall be configurable for on & off delays as per requirement.

d) The numerical relay shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.

e) At least 100 time tagged events / records shall be stored with time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.

f) Automatic testing, power on diagnostics with continuous monitoring shall be provided in the IED to ensure high degree of reliability. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be shall be available on the user interface.

g) The alarm/status of each individual protection function and trip operation including measurement values shall be communicated to the SAS/SCADA system.

h) Sequence of events shall have 1ms resolution at device level.

i) Measurement accuracy shall be 1%.

j) It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.

3.10 Painting

Painting of panels shall be as specified in Section-GTR.
4.00 ETHERNET SWITCH

a) Ethernet switches shall be ‘substation hardened’, and shall comply with IEC61850 for communications with IEDs. The Ethernet switches shall be of managed type with two (2) No. of Fiber optic cable ports and at least Sixteen (16) Copper ports to achieve the LAN configuration. More no. of switches or higher ports switch can also be supplied to meet all IEDs & Multi-function meters requirements for the LAN. The Ethernet switches shall have features to support the redundant rings. These switches shall be mounted in the switchgear Panels. The FO ports shall be Single-mode 1000Mbps ports. Copper ports shall be 10/100Mbps ports.

b) Necessary software for configuration and real-time network monitoring shall be provided along with the Ethernet switches.

5.00 POWER CABLE TERMINATION

a) Cable termination compartment shall receive the stranded Aluminium conductor, XLPE insulated, shielded, armored, PVC jacketed, single core / three core, unearthed / earthed grade HT power cable(s) as specified in Section -Project.

b) Adequate clearance shall be kept between the cable lug bottom ends and gland plates for stress cone formation for XLPE cables. Inter-phase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnection of cables. Dimensional drawing of cable connection compartment showing the location of lug, glands, gland plates etc. and the electrical clearances available shall be submitted during detail engineering.

c) Cable termination compartment shall have provision for termination of power cables of sizes indicated in the bidding documents. Cable entry shall generally be from the bottom; however, this shall be finalized during detail engineering.

d) Necessary cable termination plugs shall be part of Indoor switchgear panel supplier for all panels. Scope also includes Panel terminal ends jointing/connection with HT cables.

6.00 GENERAL REQUIREMENTS FOR ERECTION

6.01 Contractor shall move all equipment into the respective rooms through the regular door or openings specifically provided for this purpose. No parts of structure shall be utilized to lift or erect any equipment without prior permission of Engineer-in-charge.

6.02 Switchgear shall be installed on finished surfaces, concrete or steel sills. Contractor shall be required to install and align any channel sills which form part of foundations. Minor modifications to foundations shall be carried out by the Contractor. Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments and relays are supplied loose along with switchgear, they shall be mounted only after the associated switchgear panels have been erected and aligned. The blocking materials, employed for safe transit of instrument and relays shall be removed after ensuring that panels have been completely installed and no further movement of the same would be necessary. Any damage shall be immediately reported to Engineer.
6.03 Contractor shall include all special tools required for regular operation & routine maintenance of switchgear.

7.00 CONFIGURATION OF INDOOR SWITCHGEAR PANELS (GIS TYPE)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Equipment</th>
<th>Unit</th>
<th>IP1 I/C</th>
<th>IP2 O/G</th>
<th>IP3 LT TR</th>
<th>IP4 B/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CB, Three position Isolator &amp; Earth Switch (3-Ph)</td>
<td>Set</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>CB Spring charge indicator</td>
<td>No.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>ON/OFF indicators for CB</td>
<td>Set</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>ON/OFF Indicators for three position GIS Isolator &amp; Earth Switch</td>
<td>Set</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>ON/OFF indicators for AIS Line Isolator &amp; Line Earth Switch</td>
<td>Set</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6.</td>
<td>CT (1-Phase)</td>
<td>Nos.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>7.</td>
<td>VT (1-Phase)</td>
<td>Nos.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>8.</td>
<td>Multi Function Meter</td>
<td>No.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9.</td>
<td>Control switch for Circuit Breaker</td>
<td>No.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10.</td>
<td>Control Switches for Three position GIS Isolator &amp; Earth switch (Electrical)</td>
<td>Set</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>DC healthy lamp (white)</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12.</td>
<td>Trip circuit healthy lamp</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>SF6 Gas Density indicator for each compartment (set)</td>
<td>Set</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14.</td>
<td>Capacitive Voltage Detection system (CVD)</td>
<td>Set</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>15.</td>
<td>Mimic to represent SLD</td>
<td>Set</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16.</td>
<td>Voltmeter with selector switch</td>
<td>Set</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>17.</td>
<td>Numerical protection relay (IED)</td>
<td>No.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18.</td>
<td>LAN Switches and LAN/FO Cables</td>
<td>Set</td>
<td>AS per requirement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>Cable Termination arrangement including cable end Plugs</td>
<td>Set</td>
<td>AS per requirement</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. IP1 (I/C): Panel for Transformer Incomer feeder
2. IP2 (O/G): Panel for outgoing Line Feeder
3. IP3 (LT TR): Panel for LT Transformer feeder
4. IP4 (B/S): Panel for Bus Sectionaliser
5. Location of VT (I/C or B/S Panel) shall be decided during detail engineering.
6. Numerical protection relay (IED) for all type of panels shall preferably be interchangeable to optimize mandatory spares.

8.00 TESTS

8.01 Type Tests

The contractor shall submit the reports for the following type tests on the equipment to be supplied under the contract:
A. Switchgear Panel (with Circuit Breaker installed)
   a. Short circuit duty test
   b. Short time and peak withstand current test
   c. Power frequency withstand test
   d. Lightning impulse withstand test
   e. Temperature rise test
   f. Internal Arc Test as per IEC 62271-200 (for 1 second)
   g. Measurement of resistance of main circuit
   h. Test to verify pressure relief operation of the panel (During internal arc test)
   i. Cable charging test
   j. Short circuit withstand test of earthing device

B. Circuit Breaker
   a. Mechanical Endurance Test

C. Current Transformer
   a. Short time current test
   b. Temperature rise test
   c. Lighting Impulse voltage withstand test

D. Potential Transformer
   a. Temperature rise test
   b. Lighting Impulse voltage withstand test

E. Switchgear Panel
   a. IP 4X test

8.02 Routine Tests

All acceptance and routine tests as per the specification and relevant standards IEC 62271-200 & IEC 62271-100 shall be carried out. Charges for these shall be deemed to be included in the equipment price.

The manufacturer shall furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

8.03 Commissioning Checks / Tests

After installation of panels, power and Control wiring and connections, Contractor shall perform commissioning checks as listed below to verify proper operation of switchgear / panels and correctness of all equipment in all respects. In addition, the Contractor shall carry out all other checks and tests recommended by the manufacturers.

8.03.01 General
a. Check name plate details according to specification.
b. Check for physical damage
c. Check tightness of all bolts, clamps and connecting terminals
d. Check earth connections
e. Check cleanliness of equipment
f. Check heaters are provided
g. H.V. test on complete switchboard with CT & breaker in position.
h. Check all moving parts are properly lubricated.
i. Check for alignment of busbars
j. Check continuity and IR value of space heater.
k. Check earth continuity for the complete switchgear board.

8.03.02 Circuit Breaker

a. Check alignment
b. Check correct operation
c. Check control wiring for correctness of connections, continuity and IR values.
e. Power closing / opening operation, manually and electrically
f. Closing and tripping time.
g. Trip free and anti-pumping operation.
h. IR values, resistance and minimum pick up voltage of coils.
i. Simultaneous closing of all the three phases.
j. Check electrical and mechanical interlocks provided.
k. Checks on spring charging motor, correct operation of limit switches and time of charging
l. All functional checks.

8.03.03 Current Transformers

a. Megger between windings and winding terminals to body.
b. Polarity tests.
c. Ratio identification checking of all ratios on all cores by primary injection of current.
d. Magnetization characteristics & secondary winding resistance.
e. Spare CT cores, if any to be shorted and earthed.

8.03.04 Voltage Transformers

a. Insulation resistance test.
b. Ratio test on all cores.
c. Polarity test.
d. Line connections as per connection diagram.

8.03.05 Cubicle Wiring

a. Check all switch developments.
b. It should be made sure that the wiring is as per relevant drawings. All interconnections
between panels shall similarly be checked.
c. All the wires shall be megered to earth.
d. Functional checking of all control circuit e.g. closing, tripping interlock, supervision and
alarm circuit including proper functioning of component / equipment.
e. Check terminations and connections.
f. Wire ducting.
g. Gap sealing and cable bunching.

8.03.06 Relays

a. Check internal wiring.
b. IR of all terminal body.
c. IR of AC to DC terminals
d. Check operating characteristics by secondary injection.
e. Check operation of electrical/ mechanical targets.
f. Relay settings.

9.00 SYSTEM PARAMETERS:

<table>
<thead>
<tr>
<th></th>
<th>Nominal System voltage</th>
<th>33 kV</th>
<th>11 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Highest System voltage</td>
<td>36 kV</td>
<td>12 kV</td>
</tr>
<tr>
<td>3</td>
<td>Rated Frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>4</td>
<td>Number of phases/ poles</td>
<td>Three</td>
<td>Three</td>
</tr>
<tr>
<td>5</td>
<td>System neutral earthing</td>
<td>As per Vector Group of Transformers</td>
<td>As per Vector Group of Transformers</td>
</tr>
<tr>
<td>6</td>
<td>One minute power frequency withstand voltage</td>
<td>70</td>
<td>28</td>
</tr>
<tr>
<td>7</td>
<td>1.2/50 microsecond Impulse withstand voltage</td>
<td>170 kV (peak)</td>
<td>75 kV (peak)</td>
</tr>
<tr>
<td>8</td>
<td>Short time rating for bus bars, CB, CT and switchgear Assembly..</td>
<td>25 kA (rms) for one (1) sec.</td>
<td>25 kA (rms) for one (1) sec.</td>
</tr>
<tr>
<td>9</td>
<td>Dynamic withstand rating</td>
<td>62.5 kA (peak)</td>
<td>62.5 kA (peak)</td>
</tr>
<tr>
<td>10</td>
<td>IAC Rating</td>
<td>25 kA,1.0 sec</td>
<td>25 kA, 1.0 Sec</td>
</tr>
<tr>
<td>11</td>
<td>Control supply voltage:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Trip and closing coils</td>
<td>As per Station DC Supply</td>
<td>As per Station DC Supply</td>
</tr>
<tr>
<td></td>
<td>b) Spring charging motor</td>
<td>As per Station DC Supply</td>
<td>As per Station DC Supply</td>
</tr>
<tr>
<td>12</td>
<td>Maximum ambient air temperature</td>
<td>40 deg. C</td>
<td>40 deg. C</td>
</tr>
<tr>
<td>13</td>
<td>Degree of Protection:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>HV-live parts</td>
<td>IP65</td>
<td>IP65</td>
</tr>
<tr>
<td>b)</td>
<td>Low voltage compartments</td>
<td>IP4X</td>
<td>IP4X</td>
</tr>
</tbody>
</table>

**a) CIRCUIT BREAKERS**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rated Voltage</td>
<td>33 kV</td>
<td>11 kV</td>
</tr>
<tr>
<td>2.</td>
<td>CB rated Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Incomer Breaker</td>
<td>1250A</td>
<td>1250A</td>
</tr>
<tr>
<td>b)</td>
<td>Outgoing feeder Breaker</td>
<td>1250A</td>
<td>1250A</td>
</tr>
<tr>
<td>3.</td>
<td>Short circuit breaker Current:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>A.C. component</td>
<td>25 kA</td>
<td>25 kA</td>
</tr>
<tr>
<td>b)</td>
<td>D.C. component</td>
<td>As per IS: 13118 or IEC-62271</td>
<td>As per IS: 13118 or IEC-62271</td>
</tr>
<tr>
<td>4.</td>
<td>Short Circuit making current</td>
<td>62.5 kA (peak)</td>
<td>62.5 kA (peak)</td>
</tr>
<tr>
<td>5.</td>
<td>Out of phase breaking Current capacity</td>
<td>As per IEC</td>
<td>As per IEC</td>
</tr>
<tr>
<td>6.</td>
<td>Rated line/cable charging Interrupting current at 90° Leading power factor angle</td>
<td>As per IEC</td>
<td>As per IEC</td>
</tr>
<tr>
<td>7.</td>
<td>Maximum allowable switching Over voltage under any switching Condition</td>
<td>As per IEC</td>
<td>As per IEC</td>
</tr>
<tr>
<td>8.</td>
<td>Rated small inductive current Switching capability with over Voltage less than 2.3 pu</td>
<td>As per IEC</td>
<td>As per IEC</td>
</tr>
<tr>
<td>9.</td>
<td>First pole to clear factor</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>10</td>
<td>Operating Duty</td>
<td>O-0.3 Sec-CO-3 Min-CO</td>
<td>O-0.3 Sec-CO-3 Min-CO</td>
</tr>
<tr>
<td>11</td>
<td>Total break time</td>
<td>Not more than 4 cycles</td>
<td>Not more than 4 cycles</td>
</tr>
<tr>
<td>12</td>
<td>Total make time</td>
<td>Not more than 5 cycles</td>
<td>Not more than 5 cycles</td>
</tr>
<tr>
<td>13</td>
<td>Reclosing</td>
<td>3 phase auto reclosing</td>
<td>3 phase auto reclosing</td>
</tr>
<tr>
<td>14</td>
<td>Max. difference in the instants of closing/opening contacts between poles at rated control Voltage and rated operating and quenching media pressures</td>
<td>As per IEC</td>
<td>As per IEC</td>
</tr>
<tr>
<td>15</td>
<td>Auxiliary contacts</td>
<td>2NO+2NC for Employers future use besides scheme requirement</td>
<td>2NO+2NC for Employers future use besides scheme requirement</td>
</tr>
</tbody>
</table>
16 Operating Mechanism | Motor wound spring charged stored energy type as per IEC-62271 | Motor wound spring charged stored energy type as per IEC-62271

b) CURRENT TRANSFORMER (Incomer/Bus coupler Feeder)
1. Rated primary voltage | 33kV | 11kV
2. Rated primary current | 1000A | 800A
3. Type of CT | 1-Phase | 1-Phase
4. Max temp rise | As per IEC:60044-1 | As per IEC:60044-1
5. Class of Insulation | Class E or better | Class E or better
6. One minute power frequency withstand voltage between secondary terminal & earth | 2kV | 2kV
7. No. of Secondary cores | 3 | 3

c) CURRENT TRANSFORMER (Line Feeder)
1. Rated primary voltage | 33kV | 11kV
2. Rated primary current | 300A | 300A
3. Max temp rise | As per IEC:60044-1 | As per IEC:60044-1
4. Class of Insulation | Class E or better | Class E or better
5. One minute power frequency withstand voltage between secondary terminal & earth | 2kV | 2kV
6. Nos. of Secondary cores | 2 | 2

d) CURRENT TRANSFORMER (LT Transformer feeder)
1. Rated primary Voltage | 33kV | 11kV
2. Rated primary current | 40A | 40A
3. Max temp rise | As per IEC:60044-1 | As per IEC:60044-1
4. Class of Insulation | Class E or better | Class E or better
5. One minute power frequency withstand voltage between secondary terminal & earth | 2kV | 2kV
6. Nos. of Secondary cores | 2 | 2

e) VOLTAGE TRANSFORMERS
1. Rated primary Voltage | 33kV | 11kV
2. Type | 1-phase | 1-Phase
3. Voltage ratio (kV) | (33/√3)/(0.11/√3) | (11/√3)/(0.11/√3)
4. Rated Voltage Factor | 1.2 continuous and 1.5 for 30 seconds | 1.2 continuous and 1.5 for 30 seconds
### Requirement for 33kV Current Transformers

#### Incomer / Bus Coupler Feeder

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current ratio</td>
<td>1000-500/1</td>
<td>1000-500/1</td>
<td>1000-500/1</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>0.2S class</td>
<td>5P20</td>
<td>PS</td>
</tr>
<tr>
<td>Knee point voltage (at minimum ratio)</td>
<td>-</td>
<td>-</td>
<td>400V</td>
</tr>
<tr>
<td>Rated burden</td>
<td>7.5VA</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

#### Line Feeder

<table>
<thead>
<tr>
<th></th>
<th>Metering</th>
<th>O/C &amp; E/F Protn.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current ratio</td>
<td>300-150/1</td>
<td>300-150/1</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>0.2S class</td>
<td>5P20</td>
</tr>
<tr>
<td>Knee point voltage (at minimum ratio)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rated burden</td>
<td>7.5VA</td>
<td>-</td>
</tr>
</tbody>
</table>

#### LT Transformer Feeder

<table>
<thead>
<tr>
<th></th>
<th>Metering</th>
<th>O/C &amp; E/F Protn.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current ratio</td>
<td>40-20/1</td>
<td>40-20/1</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>0.2S class</td>
<td>5P20</td>
</tr>
<tr>
<td>Knee point voltage (at minimum ratio)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rated burden</td>
<td>7.5VA</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: The ratings indicated for instrument transformers are tentative only and may be changed to meet the functional requirements.

### Requirement for 11kV Current Transformers

#### Incomer / Bus Coupler Feeder

<table>
<thead>
<tr>
<th></th>
<th>Metering</th>
<th>O/C &amp; E/F Protn.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current ratio</td>
<td>40-20/1</td>
<td>40-20/1</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>0.2S class</td>
<td>5P20</td>
</tr>
<tr>
<td>Knee point voltage (at minimum ratio)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rated burden</td>
<td>7.5VA</td>
<td>-</td>
</tr>
</tbody>
</table>

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**ICB/PMD/MCTLP/018/19-01**

Procurement of Manang Khudi Substation

Single-Stage, Two-Envelope

Page 17 of 20
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current ratio</td>
<td>800-400/1</td>
<td>800-400/1</td>
<td>800-400/1</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>0.2S class</td>
<td>5P20</td>
<td>PS</td>
</tr>
<tr>
<td>Knee point voltage (at minimum ratio)</td>
<td>-</td>
<td>-</td>
<td>400V</td>
</tr>
<tr>
<td>Rated burden</td>
<td>7.5VA</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**LINE FEEDER**

<table>
<thead>
<tr>
<th></th>
<th>Metering</th>
<th>O/C &amp; E/F Prot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current ratio</td>
<td>300-150/1</td>
<td>300-150/1</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>0.2S class</td>
<td>5P20</td>
</tr>
<tr>
<td>Knee point voltage (at minimum ratio)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rated burden</td>
<td>7.5VA</td>
<td>-</td>
</tr>
</tbody>
</table>

**REQUIREMENT FOR 11KV CURRENT TRANSFORMERS (LT TRANSFORMER FEEDER)**

<table>
<thead>
<tr>
<th></th>
<th>Metering</th>
<th>O/C &amp; E/F Prot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current ratio</td>
<td>40-20/1</td>
<td>40-20/1</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>0.2S class</td>
<td>5P20</td>
</tr>
<tr>
<td>Knee point voltage (at minimum ratio)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rated burden</td>
<td>7.5VA</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: The ratings indicated for instrument transformers are tentative only and may be changed to meet the functional requirements.

10.00 **INPUT SIGNAL TO SAS SYSTEM**

The following digital input of 33kV & 11kV Indoor switchgear bays shall be provided through IEDs in the SAS system:

i) Status of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Trip circuit faulty
v) Bus VT FUSE Fail
vi) Back-up overcurrent & earth fault protection Operated
vii) DC source fail

11.00 **MULTIFUNCTION METER**

The Multifunction meter shall have feature to measure KV, I, MW, MVAR, PF, MWhr, MVARhr with accuracy class of 0.5. Further, multifunction meter shall have bi-directional feature to register/record MWhr values.

12.00 **MANDATORY SPARES**
<table>
<thead>
<tr>
<th>S.I.N</th>
<th>Equipment</th>
<th>Unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>33kV</td>
<td>11kV</td>
</tr>
<tr>
<td>1.</td>
<td>CB Spring charge indicator</td>
<td>No.</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>ON/OFF indicator for CB (Mechanical)</td>
<td>No.</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>ON/OFF indicator for GIS Isolator/Earth Switch (Mechanical)</td>
<td>No.</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>CT (1-Phase)</td>
<td>No.</td>
<td>1 No. of Each type</td>
</tr>
<tr>
<td>5.</td>
<td>VT (1-Phase)</td>
<td>No.</td>
<td>1 No. of Each type</td>
</tr>
<tr>
<td>6.</td>
<td>Multi Function Meter</td>
<td>No.</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>Control switch for Breaker</td>
<td>Nos.</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Control switch for GIS Isolator</td>
<td>Nos.</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Control switch for GIS Earth Switch</td>
<td>Nos.</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>DC healthy lamp (white)</td>
<td>Nos.</td>
<td>5</td>
</tr>
<tr>
<td>11.</td>
<td>Trip circuit healthy lamp</td>
<td>Nos.</td>
<td>5</td>
</tr>
<tr>
<td>12.</td>
<td>Voltmeter with selector switch</td>
<td>No.</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>Numerical protection relay (IED)</td>
<td>No.</td>
<td>1 No. of Each type</td>
</tr>
<tr>
<td>14.</td>
<td>Indicator for Line Isolator &amp; Earth Switch</td>
<td>Nos.</td>
<td>5</td>
</tr>
<tr>
<td>15.</td>
<td>LAN Switch</td>
<td>No.</td>
<td>1</td>
</tr>
<tr>
<td>16.</td>
<td>Trip coil assembly</td>
<td>Now.</td>
<td>2</td>
</tr>
<tr>
<td>17.</td>
<td>Closing coil assembly</td>
<td>Nos.</td>
<td>2</td>
</tr>
<tr>
<td>18.</td>
<td>SF6 gas density indicator</td>
<td>Nos.</td>
<td>2</td>
</tr>
</tbody>
</table>
CHAPTER 23 : MISCELLANEOUS ITEMS

Content

1) MOBILE CRANE ............................................................................................................. 1
   i) GENERAL DESCRIPTION ......................................................................................... 1
   ii) DETAILED TECHNICAL SPECIFICATION OF CRANE .................................. 1

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MISCELLANEOUS ITEMS

1) MOBILE CRANE

i) GENERAL DESCRIPTION

The bidder shall supply and delivery of one number of all-terrain mobile crane of max. lifting capacity between 220-250 tone and accessories suitable for lifting heavy equipment such as transformers at site (Khudi, Lamjung). The crane shall have two cab (carrier cab and superstructure cab). Carrier cab shall be two-man full width with safety glass with facilities of air-conditioned, radio etc. Superstructure cab shall be panoramic cab of composite structure with safety glass windows. Crane shall have four point, double telescopic hydraulic outriggers with controls on both sides of carrier and in superstructure cab. Boom shall be telescopic boom with minimum 6 sections, made of high tensile, fine-grained steel, consisting of 1 base section and remaining telescoping sections extended by means of a single telescopic cylinder. All telescope sections extendable under partial load. Derricking system shall be one/ two double acting hydraulic cylinder with integral brake and holding valve. Hydraulic system shall be three circuit diesel hydraulic system with 1 double axial piston pump, 1 axial piston pump and 1 gear pump, oil cooler. Control of lifting shall be Electrical, joy-stick levers for simultaneous operation of crane motions. Slewing system shall be axial piston motor with three-stage planetary gear equipped with automatic service and a parking brake. Counterweight shall be divisible, assembled and disassembled by hydraulic cylinders controlled from superstructure cab.

Technical Specifications are given in Table below. Bidder shall provide description of offered vehicle in the provided column below.

ii) DETAILED TECHNICAL SPECIFICATION OF CRANE

<table>
<thead>
<tr>
<th>SN</th>
<th>Parameters</th>
<th>Specification / Requirements</th>
<th>Offered Technical Data Sheet To Be Filled By The Bidder</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Make</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Manufacturing standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>General</td>
<td>Right hand steering, 5 axle, minimum 4 no. steered suitable for operation under rough working conditions and adverse climatic condition at operating altitude ranging from 80 m to 2500 m (msl) and ambient temperature varying between -10°C to 50°C. Transportation in high hilly region with super-elevated roads should be feasible and of reputed manufacturing company.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>Type of crane</td>
<td>All terrain, tyre mounted, telescopic boom, hydraulic mobile crane. The crane shall be able to move on all types of road.</td>
<td></td>
</tr>
</tbody>
</table>
| **6** | Capacity - Bidder is to submit the load chart.  
2.(a) Load capacities at various radius and boom length | 220 to 250 MT at radius between 3.0 m over rear on out rigger without any special attachment. |
| **7** | Turning radius (at front chassis corner) | Max 14 meter on the extreme chassis corner with all wheel streer. |
| **8.0** | **SUPER STRUCTURE SPECIFICATION** |   |
| **8.1** | Boom shall be fully Hydraulic Telescopic & shall be hydraulically extendable under partial load and all sections shall be extendable independently. The telescoping system has to have safety locking system. The hydraulic telescoping of the boom is possible by automatic to preselected boom length by switch system. Bidder to indicate whether such telescoping is possible manually by joystick or not for information only. Slide parts of telescoping boom should be maintenance free. | Min 60 Meter |
| **8.2** | Swing away Jib in section | 10 - 19 meters (+/- 5%) |
| **8.3** | Slew speed | 0 - 1.2 RPM. |
| **8.4** | Main Hoist speed | Min 80 meters per minute single line |
| **8.5** | Jib Functioning | Required to facilitate functioning of hook block on jib section. Also shall include hoist camera and working light |
| **8.6** | Counter weight | Counterweight shall be divisible, |
| 8.7 | Hydraulic system | Hydraulically assembled and disassembled by hydraulic cylinders controlled from superstructure cab. |
| 8.8 | Safety devices | Hydraulic circuit has to be with automatic output control. There has to be cut off device when reaching the rated capacity. Electronic control is to stop all danger operation in case of reaching the rated capacity. Safe load indicator with visual display in operator’s cabin for maximum allowed load, actual load on the hook, operating radius, boom length, height under the sheave. Error detection system has to be there. Safety device has to be there against pipe and hose rupture. Test system facility for checking all sensors in crane operator cabin. Fault diagnostic system has to be there with ready to start indication facility. There has to be hoist limit switch also. |
| 8.9 | Crane engine | Suitable water cooled diesel engines conforming to 97/68/EG/EPA/CARB Tier 3a/EUROMOT 3a/3b/ Stage IV Tier 4 Min 145 kW |
| 8.10 | Hook block size/capacity | Bidder to minimum supply following hook block along with the crane (Price shall be inclusive in the quoted price of crane)
1. 220 MT (+/- 10%) or above suitable for the offered crane model
2. 100 MT (+/- 10%)
3. 30 MT (+/- 10%) |
| 8.11 | Control system | The control system for load handling shall be automatic and manual both. Selection facility shall be there. Operation of any three of the four crane motions simultaneously i.e. a) load hoisting / lowering, b) boom luffing / derricking, c) boom telescoping / retracting and d) slewing must be possible. |

### 9.0 CARRIER SPECIFICATION

#### 9.1 General

Min. 8 cylinder, Inline Water cooled, Diesel engine piston displacement
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.2</td>
<td>Gear box / Transmission</td>
<td>Multiple speed gear box with automatic gear sifting.</td>
</tr>
<tr>
<td>9.3</td>
<td>No. of axles</td>
<td>Maximum five (5) number.</td>
</tr>
<tr>
<td>9.4</td>
<td>Tyre details</td>
<td>Suitable for crane configuration. (Vendor to provide tyre details)</td>
</tr>
<tr>
<td>9.5</td>
<td>Maximum Travel speed</td>
<td>Min 45 km/hr</td>
</tr>
<tr>
<td>9.6</td>
<td>Brake</td>
<td>Brake shall be of pneumatic dual circuit on multiple wheels during running / operation and during parking, brake shall be acting on at least 50% of total number of axles.</td>
</tr>
<tr>
<td>9.7</td>
<td>Outrigger type</td>
<td>Four point support having hydraulically controlled outrigger and also having independent horizontal &amp; vertical movement for each outrigger. Working light for each outrigger beam. Electronic level indicator with automatic leveling system has to be there &amp; also readout of outrigger pad load in superstructure &amp; carrier.</td>
</tr>
<tr>
<td>9.8</td>
<td>Inclination display</td>
<td>Electronic inclination display to show crane leveling status has to be there.</td>
</tr>
<tr>
<td>9.9</td>
<td>Suspension</td>
<td>Hydro-pneumatic independent suspension has to be there on all axles &amp; hydraulically lockable</td>
</tr>
<tr>
<td>9.10</td>
<td>Travel of suspension system</td>
<td>Each suspension cylinder is able to move individually to take care of different road conditions</td>
</tr>
<tr>
<td>9.11</td>
<td>Level adjustment in travel mode</td>
<td>It shall be able to activate automatically from the front cabin</td>
</tr>
<tr>
<td>9.12</td>
<td>Chassis</td>
<td>Custom built, torsion resistant made of high strength steel.</td>
</tr>
<tr>
<td>9.13</td>
<td>Cabin</td>
<td>Comfortable &amp; Rigid Air Conditioned cabin with safety glass windows</td>
</tr>
<tr>
<td>9.14</td>
<td>Steer</td>
<td>Minimum 4 axle</td>
</tr>
<tr>
<td>10</td>
<td>Safety devices</td>
<td>'Lift Adjuster' to prevent dangerous swinging of the load, load moment device (LMD), anemometer, working area limiter, hoist limit switch, lower limit switch and drum turn indicator, safety valves against pipe and hose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rupture, holding valves on hydraulic cylinders.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>11</td>
<td>Software</td>
<td>Software to simulate load handling scheme on computer monitor is to be supplied as standard item along with the supply. The software shall be in CD and shall also be operable on standalone normal personal computer</td>
</tr>
<tr>
<td>12</td>
<td>Variable outrigger extension</td>
<td>Shall have the capability to work on outrigger with extension of individual outrigger to the extent of available space without any step (continuous). Individual outrigger should be extendable arbitrarily to each other. Crane system should be able to calculate the relevant capacity according to each arbitrary outrigger position which should be displayed in the operator cabin. The safety system of the crane should work accordingly.</td>
</tr>
<tr>
<td>13</td>
<td>Essential Accessories</td>
<td><strong>D Shackles</strong> – 50 Tone -5 Nos 20 Ton – 5 Nos.  <strong>Eye &amp; Eye nylon lifting slings</strong> – 12 feet length, 25 &amp; 40 ton capacity – 4 Nos  <strong>WIRE ROPE SLINGS</strong> – 12 feet, 50 ton capacity – 4 Nos.  <strong>Wire rope and sling with 4-leg bridle</strong> – 10 feet length, 200 ton – 1 No.  <strong>Tyre</strong>: 2 number of spare tyre</td>
</tr>
<tr>
<td>14</td>
<td>Instructions</td>
<td>All signs and instructions in the equipment shall be in English</td>
</tr>
<tr>
<td>15</td>
<td>Manuals</td>
<td>1. One printed copy of the Operator's and Owner's Instructions and Maintenance manual in English with each equipment 2. Three printed copies of following manuals in English:  - Spare parts catalogue  - Comprehensive workshop manual</td>
</tr>
<tr>
<td>16</td>
<td>Tools</td>
<td>A set of tools including hydraulic jack with handle as required for general maintenance shall be provided.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>17</td>
<td>Color</td>
<td>As approved by the Project</td>
</tr>
<tr>
<td>18</td>
<td>Initial Service</td>
<td>The supplier shall provide all necessary filters and spare parts including lubricants with the equipment, required for the first two services, after the equipment has been commissioned and accepted</td>
</tr>
</tbody>
</table>
| 19 | Proven performance | - The machine offered shall be a current model under standard production by the manufacturer for at least three years.  
- The bidder shall provide the manufacturer's data of the performance of the unit to include the fuel consumption, performance curve of the engine and production capacity of the unit. |
| 20 | Related Service | The supplier shall arrange and conduct training by the experts as per BPS (Engineers, Mechanic/Operator) of the Project, in operation, maintenance and/or repair of the equipment supplied after delivery for five days in Nepal. The training content should cover all the necessary topics includes following.  
i. General introduction of equipment features and its components  
ii. Operation and application of equipment, and related safety features  
iii. Servicing/ Schedule maintenance  
iv. Introduction, servicing, maintenance of Engine, Power train, Hydraulic, Brake, Cooling, Electrical, Control system,  
v. Trouble shooting and diagnosis of all the systems of equipment |
2) EMF meter

i) General Overview: -

It is mandatory that specifications of EMF meter shall be standardized and approved by the international/national authority. Bidder has to furnish valid certification before the supply of EMF meter.

ii) Overall Specification: -

- The EMF meter device is able to operate for an acceptable duration of time for the inspection being conducted. Battery capacity should be 9V.
- The device must be hand launched and electrically powered.
- The EMF meter should measure magnetic field radiation at different bandwidth from 30 Hz to 2000Hz.
- The EMF meter must have resolution 0.001/0.01/0.1 μT
- The EMF meter should provide three axis (X,Y,Z) electromagnetic field measurement.
- The EMF meter should have USB PC interface.
- The maximum range of magnetic field measurement meter should be 220 μT.
- The maximum range of electric field measurement meter should be 20kV/m.
- The EMF meter should provide low battery indication, overload display ‘OL’, auto power off function.

iii) Technical Data Sheet
### FOR MAGNETIC FIELD MEASUREMENT METER

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Description</th>
<th>NEA Requirement</th>
<th>Bidder’s Offer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Name and Address of the Manufacturer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Model no.</td>
<td>Certified</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Weight</td>
<td>Approx. 500g</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Frequency response</td>
<td>About 30Hz to 2000Hz</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Resolution</td>
<td>0.001/0.01/0.1 μT</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Range</td>
<td>Max. 200μT</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Sensor</td>
<td>Triple axis(X,Y,Z)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Battery</td>
<td>Capacity: About 9V</td>
<td>Life: Approx. 100 hrs</td>
</tr>
<tr>
<td>9</td>
<td>Operating temperature</td>
<td>5°C to 40°C</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>USB Cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Display</td>
<td>Max. 4 digits with LCD display</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Accuracy</td>
<td>Approx. 5%</td>
<td></td>
</tr>
</tbody>
</table>

### FOR ELECTRIC FIELD MEASUREMENT METER

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Description</th>
<th>NEA Requirement</th>
<th>Bidder’s Offer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Name and Address of the Manufacturer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Model no.</td>
<td>Certified</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Weight</td>
<td>Approx. 1 kg</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Frequency response</td>
<td>About 40 Hz to 20 kHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>Max. 20kV/m</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Battery Capacity</td>
<td>About 9V</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Accuracy</td>
<td>Max. 3%</td>
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Technical Data Sheet

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POWER TRANSFORMERS

1. 220/132/33 kV, 1 Phase Autotransformer

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<td>kA</td>
<td>-</td>
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ICB/PMD/MCTLP/018/19-01  Procurement of Manang Khudi Substation  Single-Stage, Two-Envelope

Page 2 of 21
**Technical Data Sheet**

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<td>Tap control</td>
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<td>Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow</td>
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<td>LV</td>
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ICB/PMD/MCTLP/018/19-01

Procurement of Manang Khudi Substation

Single-Stage, Two-Envelope
# Technical Data Sheet

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<td>pC</td>
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<td>pC</td>
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## 2. 132/33 kV, 3 Phase Autotransformer

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<td>iii) Min. Voltage tap</td>
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<th>Description</th>
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<tbody>
<tr>
<td>LV</td>
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<td>kA</td>
<td>25</td>
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<td></td>
<td>kA</td>
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<tr>
<td>ii)</td>
<td>Lightning Impulse withstand Voltage</td>
<td>kV_p</td>
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<td>550</td>
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<td>HV</td>
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<td>kV_p</td>
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<tr>
<td>LV</td>
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<td>kV_p</td>
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<td>iii)</td>
<td>Switching Impulse withstand Voltage</td>
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<td>460</td>
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<td>iv)</td>
<td>One Minute Power Frequency withstand Voltage</td>
<td>kV_{rms}</td>
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<tr>
<td>HV</td>
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<td>kV_{rms}</td>
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<td>v)</td>
<td>Neutral Grounding</td>
<td>Solidly grounded</td>
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<tr>
<td>vi)</td>
<td>Insulation</td>
<td></td>
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<tr>
<td>HV</td>
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<tr>
<td>LV</td>
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<td>vii)</td>
<td>Tan delta of winding</td>
<td>%</td>
<td>&lt;0.5%</td>
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<td>1.15</td>
<td>Vector Group (3–ph) (unless specified differently elsewhere)</td>
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<td>YNynO</td>
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<td>1.16</td>
<td>Tap Changer</td>
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<td>OLTC</td>
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<td>i)</td>
<td>Tap Range &amp; No. of steps</td>
<td></td>
<td>-15% to +5% of HV variation in the step of 1.25%, 16 steps</td>
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<td>ii)</td>
<td>Location of Tap changer</td>
<td></td>
<td>On Neutral side of 132 kV winding</td>
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<td>iii)</td>
<td>Design</td>
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<td>Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I</td>
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<tr>
<td>iv)</td>
<td>Tap control</td>
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<td>Full capacity on load tap changer suitable for group/independent, remote/local electrical and local manual operation and bi-directional power flow.</td>
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<td>1.17</td>
<td>Bushings</td>
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<td>i)</td>
<td>Rated voltage</td>
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<td>HV</td>
<td>kV</td>
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<td>Rated current (Min.)</td>
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<td>HV</td>
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<tr>
<td></td>
<td>Neutral</td>
<td>A</td>
<td>1250</td>
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<td>iii)</td>
<td>Lightning Impulse withstand Voltage</td>
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<td>HV</td>
<td>kVp</td>
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<td>kVp</td>
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<td>HV</td>
<td>kVrms</td>
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<td>LV</td>
<td>kVrms</td>
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<td>Neutral</td>
<td>kVrms</td>
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<td>v)</td>
<td>Minimum total creepage distances</td>
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<td>HV</td>
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<tr>
<td></td>
<td>LV</td>
<td>mm</td>
<td>900</td>
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<tr>
<td>vi)</td>
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<td>vii)</td>
<td>Tan delta of bushing HV</td>
<td>%</td>
<td>&lt;0.4</td>
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<td>1.18</td>
<td>Max Partial discharge level at ( U_m ) HV</td>
<td>pC</td>
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<td>1.19</td>
<td>Max Noise level at rated voltage and at principal tap full load and cooling active</td>
<td>dB</td>
<td>75</td>
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### 3. CIRCUIT BREAKER

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<tr>
<td></td>
<td></td>
<td>220kV system</td>
<td>132 kV system</td>
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<tr>
<td>1.</td>
<td>Make</td>
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<tr>
<td>2.</td>
<td>Model / Item no.</td>
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<td></td>
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<tr>
<td>3.</td>
<td>Manufacturing Standard</td>
<td></td>
<td></td>
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<tr>
<td>4.</td>
<td>Country of Origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Rated voltage kV (rms)</td>
<td>245</td>
<td>145</td>
</tr>
<tr>
<td>6.</td>
<td>Rated frequency (Hz)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>7.</td>
<td>No. of poles</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>Type of circuit breaker</td>
<td>SF6 insulated.</td>
<td>SF6 insulated.</td>
</tr>
<tr>
<td>9.</td>
<td>Rated continuous current (A) at an ambient temperature of 50°C</td>
<td>1600/2400/3000/4000 (as applicable)</td>
<td>800/1200/1600/2000 (as applicable)</td>
</tr>
<tr>
<td>10.</td>
<td>Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening conditions as</td>
<td>40 kA (As applicable)</td>
<td>31.5 kA (As applicable)</td>
</tr>
</tbody>
</table>
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<tr>
<td>11.</td>
<td>Symmetrical interrupting capability kA (rms) (As applicable)</td>
</tr>
<tr>
<td>12.</td>
<td>Rated short circuit making current kAp (As applicable)</td>
</tr>
<tr>
<td>13.</td>
<td>Short time current carrying capability for one second kA (rms) (As applicable)</td>
</tr>
<tr>
<td>14.</td>
<td>Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of U/√3 and 1.4 as per IEC-62271-100)</td>
</tr>
<tr>
<td>15.</td>
<td>First pole to clear factor</td>
</tr>
<tr>
<td>16.</td>
<td>Rated break time as IEC (ms)</td>
</tr>
<tr>
<td>17.</td>
<td>Total break time (ms)</td>
</tr>
<tr>
<td>18.</td>
<td>Total closing time (ms)</td>
</tr>
<tr>
<td>19.</td>
<td>Rated operating duty cycle</td>
</tr>
<tr>
<td>20.</td>
<td>Reclosing</td>
</tr>
<tr>
<td>21.</td>
<td><strong>Rated insulation levels</strong></td>
</tr>
<tr>
<td></td>
<td>Full wave impulse withstand (1.2 /50 µs) between line terminals and ground:</td>
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</table>
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<thead>
<tr>
<th>Requirement</th>
<th>Make/Model</th>
<th>Manufacturing Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full wave impulse withstand (1.2 /50 µs) Between terminals with circuit breaker open:</td>
<td>±1050 kVp</td>
<td>±750 kVp</td>
</tr>
<tr>
<td>Rated switching impulse withstand voltage (250/2500 µs) Dry &amp; wet.</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Rated switching impulse withstand voltage (250/2500 µs) Dry &amp; wet Between terminals with circuit breaker open:</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>One minute power frequency withstand voltage between line terminals and ground</td>
<td>460 kV rms.</td>
<td>275 kV rms</td>
</tr>
<tr>
<td>One minute power frequency withstand voltage between terminals with circuit breaker open</td>
<td>530 kV rms.</td>
<td>315 kV rms</td>
</tr>
<tr>
<td>22. Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 266 kV (Micro volts)</td>
<td>1000 µV</td>
<td>500 µV</td>
</tr>
<tr>
<td>23. Max. difference in the instants of closing/opening of contacts (ms) between poles</td>
<td>As per IEC</td>
<td>As per IEC</td>
</tr>
<tr>
<td>24. Trip coil and closing coil voltage with variation as specified in Sec. GTR</td>
<td>220 V DC</td>
<td>220 V DC</td>
</tr>
<tr>
<td>25. Rating of Auxiliary contacts</td>
<td>10A at 220 V DC</td>
<td>10A at 220 V DC</td>
</tr>
<tr>
<td>26. Breaking capacity of Aux. Contacts less than 20 ms.</td>
<td>10A at 220 V DC</td>
<td>10A at 220 V DC</td>
</tr>
<tr>
<td>27. System neutral earthing</td>
<td>Solidly Gound</td>
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### 4. DISCONNECTORS/ ISOLATORS

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<tr>
<td></td>
<td></td>
<td>220 kV</td>
<td>132kV</td>
</tr>
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<td>3</td>
<td>Manufacturing Standard</td>
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<td>4</td>
<td>Rated voltage (rms) Un</td>
<td>245 kV</td>
<td>145 kV</td>
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<td>5</td>
<td>Rated frequency</td>
<td>50 HZ</td>
<td>50 Hz</td>
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<tr>
<td>6</td>
<td>System earthing</td>
<td>Effectively earthed</td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>7</td>
<td>Type</td>
<td>SF6 insulated</td>
<td>SF6 insulated</td>
</tr>
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<td>8</td>
<td>Rated continuous current (A) at 50°C ambient temp. (as applicable)</td>
<td>1600/2400/3000/4000A</td>
<td>800/1200/1600/2000A</td>
</tr>
<tr>
<td>9</td>
<td>Rated short time withstand current of isolator and earth switch (as applicable)</td>
<td>40 kA for 1 Sec.</td>
<td>31.5 kA for 1 second</td>
</tr>
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<td>10</td>
<td>Rated dynamic short circuit withstand current of isolator and earth switch (as applicable)</td>
<td>1125/00 kA</td>
<td>80 kA</td>
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<td>132kV</td>
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<td>220 kV</td>
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<td></td>
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<tr>
<td>132kV</td>
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<td>earth switch (As applicable)</td>
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<td>2.</td>
<td>Rated insulation level:</td>
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<td>11.</td>
<td>One minute power freq. Withstand voltage: To earth:</td>
<td>460 kV rms.</td>
<td>275 kV rms.</td>
</tr>
<tr>
<td>12.</td>
<td>One minute power freq. Withstand voltage: Across isolating distance</td>
<td>530 kV rms.</td>
<td>315 kV rms.</td>
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<td>13.</td>
<td>1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) To earth:</td>
<td>±1050 kVp</td>
<td>±650 kVp</td>
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<tr>
<td>14.</td>
<td>1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity) : Across isolating distance</td>
<td>±1200 kVp</td>
<td>±750 kVp</td>
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<td>15.</td>
<td>Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry &amp; wet : between line</td>
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<td>终端s and ground:</td>
<td>220 kV</td>
<td>132kV</td>
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<td></td>
<td>Rated switching impulse withstand voltage (250/2500 micro-sec.) Dry &amp; wet</td>
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<td>N.A</td>
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<tr>
<td></td>
<td>:Between terminals with Isolator open:</td>
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<td>12.</td>
<td>Mechanical Endurance clause as per IEC</td>
<td>M2</td>
<td>M1</td>
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<td>13.</td>
<td>No. of spare auxiliary contacts on each isolator</td>
<td>4 NO and 4 NC</td>
<td>4 NO and 4 NC</td>
</tr>
<tr>
<td>14.</td>
<td>No. of spare auxiliary contacts on each earthing switch</td>
<td>4 NO and 4 NC</td>
<td>4 NO and 4 NC</td>
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### 5. CURRENT TRANSFORMERS

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<td>132kV</td>
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<tr>
<td>a)</td>
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<tr>
<td>b)</td>
<td>Model / Item no.</td>
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<tr>
<td>c)</td>
<td>Manufacturing Standard</td>
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<td>d)</td>
<td>Country of Origin</td>
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<tr>
<td>4.</td>
<td>Rated voltage Un</td>
<td>245 kV (rms)</td>
<td>145 kV (rms)</td>
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<td>Rated frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
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<td>6.</td>
<td>System neutral earthing</td>
<td>Effectively Earthed</td>
<td>Effectively Earthed</td>
</tr>
<tr>
<td>7.</td>
<td>Rated short time thermal current for 1 second (as applicable)</td>
<td>40 kA</td>
<td>31.5 kA</td>
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<td>8.</td>
<td>Rated dynamic current</td>
<td>100 kA p.</td>
<td>78.75kA</td>
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<tr>
<td>9.</td>
<td>Rated insulation levels</td>
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<tr>
<td>i.</td>
<td>1.2/50 micro second impulse voltage</td>
<td>±1050 kVp</td>
<td>±650 kVp</td>
</tr>
<tr>
<td>ii.</td>
<td>one minute power frequency withstand voltage</td>
<td>460 kV (rms)</td>
<td>275 kV (rms)</td>
</tr>
<tr>
<td>10.</td>
<td>Maximum temperature rise over an ambient temperature of 40°C</td>
<td>As per IEC 60044-1</td>
<td>As per IEC 60044-1</td>
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<tr>
<td>11.</td>
<td>Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz</td>
<td>1000 µV</td>
<td>500 µV</td>
</tr>
<tr>
<td>12.</td>
<td>One minute power frequency withstand voltage between sec. Terminal &amp; earth</td>
<td>3 kV (rms)</td>
<td>3 kV (rms)</td>
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<tr>
<td>13.</td>
<td>Partial discharge level</td>
<td>5 pico coulombs</td>
<td>5 pico coulombs</td>
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</tbody>
</table>
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6. VOLTAGE TRANSFORMERS

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<td>132 kV</td>
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<td></td>
<td></td>
<td></td>
<td>220 kV</td>
</tr>
<tr>
<td>a)</td>
<td>Make</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Model / Item no.</td>
<td></td>
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</tr>
<tr>
<td>c)</td>
<td>Manufacturing Standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d)</td>
<td>Country of Origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Rated system voltage (Un)</td>
<td>245 kV (rms)</td>
<td>145 kV (rms)</td>
</tr>
<tr>
<td>2</td>
<td>Rated frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>3</td>
<td>System neutral earthing</td>
<td>Effectively earthed</td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>4</td>
<td>System fault level</td>
<td>50/40 kA (As applicable) for 1 Second.</td>
<td>31.5 kA</td>
</tr>
<tr>
<td>5</td>
<td>Rated insulation levels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>1.2/50 micro second impulse voltage</td>
<td>±1050 kVp</td>
<td>±650 kVp</td>
</tr>
<tr>
<td>ii.</td>
<td>one minute power frequency withstand voltage</td>
<td>460 kV (rms)</td>
<td>275 kV (rms)</td>
</tr>
<tr>
<td>iii.</td>
<td>250/2500 micro second switching impulse voltage (dry &amp; wet)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>One minute power frequency withstand voltage for secondary winding</td>
<td>3 kV (rms)</td>
<td>3 kV (rms)</td>
</tr>
<tr>
<td>7</td>
<td>Radio interference voltage at 1.1 Un/√3 and frequency range 0.5 to 2 MHz</td>
<td>1000 µV</td>
<td>500 µV</td>
</tr>
<tr>
<td>8</td>
<td>Rated total thermal burden</td>
<td>400 VA</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Partial discharge level</td>
<td>10 Pico coulombs</td>
<td>10 pico coulombs</td>
</tr>
</tbody>
</table>
### Technical Data Sheet

(Bidder shall compulsorily fill make, model, manufacturing standard of all major item from all proposed manufacturer. However, it is not compulsory to fill those data which are not know at bidding stage)

7. **GIS SURGE ARRESTOR**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Required</th>
<th>Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>220 kV</td>
<td>132 kV</td>
</tr>
<tr>
<td>a)</td>
<td>Make</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Model / Item no.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>Manufacturing Standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d)</td>
<td>Country of Origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Rated system voltage</td>
<td>245 kV</td>
<td>132 kV</td>
</tr>
<tr>
<td>2</td>
<td>System neutral earthing</td>
<td>Effectively earthed</td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>3</td>
<td>Rated arrestor voltage</td>
<td>216 kV</td>
<td>120 kV</td>
</tr>
<tr>
<td>4</td>
<td>Nominal discharge current</td>
<td>10 kA of 8/20 µs wave</td>
<td>10 kA of 8/20 µs wave</td>
</tr>
<tr>
<td>5</td>
<td>Rated frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>6</td>
<td>Minimum discharge capability</td>
<td>5 KJ/kV (referred to rated arrestor)</td>
<td>5 KJ/kV (referred to rated arrestor)</td>
</tr>
<tr>
<td>7</td>
<td>Continuous operating voltage at 50°C</td>
<td>168 kV</td>
<td>102 kV</td>
</tr>
<tr>
<td>8</td>
<td>Min. switching surge residual voltage</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. switching surge residual voltage</td>
<td>500 kVp</td>
<td>280 kVp</td>
</tr>
<tr>
<td>9</td>
<td>Max. residual voltage at 5 kA</td>
<td>560 kVp</td>
<td>310 kVp</td>
</tr>
<tr>
<td>10</td>
<td>Max. residual voltage at 10 kA nominal discharge current</td>
<td>600 kVp</td>
<td>330 kVp</td>
</tr>
<tr>
<td>11</td>
<td>Max. residual voltage at 20 kA nominal discharge current</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Steep fronted wave residual voltage</td>
<td>650 kVp</td>
<td>10 kA</td>
</tr>
</tbody>
</table>
## Technical Data Sheet

(Bidder shall compulsorily fill make, model, manufacturing standard of all major item from all proposed manufacturer. However, it is not compulsory to fill those data which are not know at bidding stage)

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<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
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<th>Offered</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>220 kV</td>
<td>132 kV</td>
</tr>
<tr>
<td>14</td>
<td>Long duration discharge class</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>High current short duration test value (4/10 micro second wave)</td>
<td>100 kAp</td>
<td>100 kAp</td>
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<tr>
<td>16</td>
<td>Current for pressure relief test</td>
<td>50kA/50kA (as applicable)</td>
<td>31.5 kA</td>
</tr>
<tr>
<td>17</td>
<td>Prospective symmetrical fault current</td>
<td>40 kA rms for 0.2 Sec</td>
<td>As per IEC</td>
</tr>
<tr>
<td>18</td>
<td>Pressure relief class:</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>19</td>
<td>RIV at ( 1.1 \frac{U}{\sqrt{3}} ) kV rms (micro volts)</td>
<td>Less than 500</td>
<td>Less than 500</td>
</tr>
<tr>
<td>20</td>
<td>Partial discharge at ( 1.05 ) COV (pC)</td>
<td>Not more than 5</td>
<td>Not more than 5</td>
</tr>
<tr>
<td>21</td>
<td>Reference ambient temp.</td>
<td>50 °C</td>
<td>50 °C</td>
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8. **SF6/AIR BUSHING**

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<th>Offered</th>
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<td></td>
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<td>220 kV</td>
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<tr>
<td>a)</td>
<td>Make</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Model / Item no.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>Manufacturing Standard</td>
<td></td>
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</tr>
<tr>
<td>d)</td>
<td>Country of Origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Rated Voltage (kV)</td>
<td>245 kV (rms)</td>
<td>145 kV (rms)</td>
</tr>
<tr>
<td>2</td>
<td>Rated Current (Amp)</td>
<td>2400/1600</td>
<td>800/1200</td>
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<tr>
<td>3</td>
<td>1.2/50 micro second impulse voltage (Lightning impulse withstand voltage)</td>
<td>1050 kVp</td>
<td>630 kVp</td>
</tr>
<tr>
<td>4</td>
<td>250/2500 micro second switching impulse voltage</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
## Technical Data Sheet

(Bidder shall compulsorily fill make, model, manufacturing standard of all major item from all proposed manufacturer. However, it is not compulsory to fill those data which are not known at bidding stage)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particular</th>
<th>Required 220 kV</th>
<th>132kV</th>
<th>Offered 220 kV</th>
<th>132kV</th>
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</thead>
<tbody>
<tr>
<td>5</td>
<td>One minute power frequency withstand voltage</td>
<td>275 kV (rms)</td>
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<tr>
<td>6</td>
<td>Minimum total creepage distance in mm</td>
<td>6125</td>
<td>3625</td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>Minimum Cantilever strength (kN)</td>
<td>8</td>
<td>5</td>
<td></td>
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</table>
Substation Automation System-TDS

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Components</th>
<th>Technical Particulars</th>
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<tbody>
<tr>
<td>1</td>
<td>Server-1&amp;2</td>
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<tr>
<td>1.1</td>
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<tr>
<td>1.2</td>
<td>Type/Model</td>
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</tr>
<tr>
<td>1.3</td>
<td>Processor</td>
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<tr>
<td>1.4</td>
<td>Processor Speed</td>
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<tr>
<td>1.5</td>
<td>HDD and RAM</td>
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</tr>
<tr>
<td>1.6</td>
<td>Operating System</td>
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</tr>
<tr>
<td>2</td>
<td>Gateway</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Manufacturer/Country</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>Type/Model</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>Processor</td>
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</tr>
<tr>
<td>2.4</td>
<td>Processor Speed</td>
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<td>2.5</td>
<td>HDD and RAM</td>
<td></td>
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<td>Operating System</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DR Workstation</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Manufacturer/Country</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>Type/Model</td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td>Processor</td>
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</tr>
<tr>
<td>3.4</td>
<td>Processor Speed</td>
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<td>3.5</td>
<td>HDD and RAM</td>
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</tr>
<tr>
<td>3.6</td>
<td>Operating System</td>
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</tr>
<tr>
<td>4</td>
<td>Operator Workstation</td>
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</tr>
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<td>4.1</td>
<td>Manufacturer/Country</td>
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<tr>
<td>4.2</td>
<td>Type/Model</td>
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</tr>
<tr>
<td>4.3</td>
<td>Processor</td>
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</tr>
<tr>
<td>4.4</td>
<td>Processor Speed</td>
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</tr>
<tr>
<td>4.5</td>
<td>HDD and RAM</td>
<td></td>
</tr>
<tr>
<td>4.6</td>
<td>Operating System</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Ethernet Switch</td>
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<td>5.1</td>
<td>Manufacturer/Country</td>
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<tr>
<td>5.2</td>
<td>Type/Model</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>Mounting Arrangement</td>
<td></td>
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<tr>
<td>6</td>
<td>Time Synchronizing Equipment</td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>Manufacturer/Country</td>
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<tr>
<td>6.2</td>
<td>Type/Model</td>
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<td>6.3</td>
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<td>Printer</td>
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<td>7.1</td>
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<td>Mounting Arrangement</td>
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### TDS-SUBSTATION AUTOMATION SYSTEM

<table>
<thead>
<tr>
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<th>Components</th>
<th>Technical Particulars</th>
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<tr>
<td>8.2</td>
<td>Type/Model</td>
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<td>8.3</td>
<td>Mounting Arrangement</td>
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</table>

Include other miscellaneous items if required

<table>
<thead>
<tr>
<th>S.N</th>
<th>Items</th>
<th>Make/Country</th>
<th>Model</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>TELE-PROTECTION &amp; COMMUNICATION EQUIPMENT</td>
<td></td>
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<td>1.1</td>
<td>Digital Protection Coupler</td>
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<tr>
<td>2</td>
<td>PBAX with following configuration as per TS</td>
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</tr>
<tr>
<td>2.1</td>
<td>2 wire subscriber interface card with capacity 32 local subscribers (along with 32 nos. Instruments)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>4 wire E &amp; M interface card with capacity 8 nos. trunks (For PLCC)</td>
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</tr>
<tr>
<td>2.3</td>
<td>E-1 interface with 2 trunks G-703</td>
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<tr>
<td>2.4</td>
<td>2 wire interface with 1 trunk (For PSTN)</td>
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<tr>
<td>2.5</td>
<td>Testing &amp; Maintenance equipment (print test kit only)</td>
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<tr>
<td>2.6</td>
<td>4 wire telephone equipment</td>
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<tr>
<td>3</td>
<td>SDH Equipment (STM-4 MADM upto 3 MSP protected directions)</td>
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<tr>
<td>3.1</td>
<td>Base Equipment (Common cards, Cross Connect/control cards, optical base cards, power supply cards, power cabling, other hardware and accessories including sub racks, patch cord, DDF etc fully equipped)</td>
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<td>Optical Interface Cards/SFP#</td>
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<td>3.3</td>
<td>Tributary cards</td>
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<td>4</td>
<td>Equipment Cabinets</td>
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<tr>
<td>5</td>
<td>Network Manager System - Craft Terminal</td>
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<tr>
<td>5.1</td>
<td>Hardware</td>
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<td>5.2</td>
<td>Software</td>
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<td>6</td>
<td>VOIP telephone instrument with one common switch (min. 4 port) including hardware and software</td>
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<td>7</td>
<td>COMMUNICATION EQUIPMENT TO SYNCHRONISING WITH KATHMANDU LDC</td>
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<td>7.1</td>
<td>Termination Equipment</td>
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<td>7.2</td>
<td>Drop/Insert Multiplexer</td>
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</tr>
<tr>
<td>7.3</td>
<td>Subscriber Line Interface Cards</td>
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<td>7.4</td>
<td>Equipment Cabinets</td>
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