GUJARAT ENERGY TRANSMISSION CORPORATION LTD.
SARADAR PATEL VIDYUT BHAVAN,
RACE COURSE, BARODA – 390 007.

TECHNICAL SPECIFICATION
FOR

420 kV, 50, 63, 80 & 125 MVar,
SHUNT REACTOR, NGR & SURGE ARRESTER
SPECIAL INSTRUCTIONS TO BIDDER

Please read following instructions carefully before submitting your bid.

1. All the drawings, i.e. elevation, side view, plan, cross sectional view etc., in AutoCAD format and manuals in PDF format, for offered item shall be submitted. Also the hard copies as per specification shall be submitted.

2. The bidder shall submit Quality Assurance Plan with the technical bid.

3. The bidder shall have to submit all the required type test reports for the offered item. In absence of this, the evaluation shall be carried out accordingly as non-submission of type test reports.

4. The bidder must fill up all the points of GTP for offered item/s. Instead of indicating “refer drawing, or as per IS/IEC”, the exact value/s must be filled in.

5. All the points other than GTP, which are asked to confirm in technical specifications must be submitted separately with the bid.

6. The bidder is required to impart training in view of manufacture, assembly, erection, operation and maintenance for offered item, at his works, to the person/s identified by GETCO, in the event of an order, free of cost. The cost of logistics will be bear by GETCO.

7. Please note that the evaluation will be carried out on the strength of content of bid only. No further correspondence will be made.

8. The bidder shall bring out all the technical deviation/s only at the specified annexure.
QUALIFYING REQUIREMENT DATA
(For Supply)

Bidder to satisfy all the following requirements.

1) The bidder shall be Original Equipment Manufacturer (OEM). The offered equipment have to be designed, manufactured and tested as per relevant IS/IEC with latest amendments.

2) The minimum requirement of manufacturing capacity of offered type, size and rating of equipment shall be THREE times tender/bid quantity. The bidder should indicate manufacturing capacity by submitting latest updated certificate of a Chartered Engineer (CE).

3) Equipment proposed shall be of similar or higher rating and in service for a minimum period of THREE (3) years and satisfactory performance certificate in respect of this is to be available and submitted.

4) The bidder should clearly indicate the quantity and Single Value Contract executed during last FIVE (5) years, for the offered equipment. Bidder should have executed one single contract during last five years for the quantity equivalent to tender/bid. The details are to be submitted in following format,

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>ITEMS SUPPLIED TO</th>
<th>ORDER REFERENCE No. &amp; DATE</th>
<th>ITEMS</th>
<th>QUANTITY</th>
<th>ORDER FULLY EXECUTED. YES/NO</th>
<th>STATUS, IF ORDER UNDER EXECUTION</th>
<th>REMARK</th>
</tr>
</thead>
</table>

e) Equipment offered shall have Type Test Certificates from 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), as per IEC / IS / technical specification. The type test reports shall not be older than FIVE years and shall be valid up to expiry of validity of offer.
SECTION - I

Specific Technical Requirements and System particulars:

1.1.0 SCOPE:

This section covers the specific technical particulars, climatic and Isoaceraunic conditions, system particulars etc., suiting to which the shunt reactor, NGR & SA as per the requirement given in the schedule of requirement, shall be offered.

The design of 3 phase 50, 63, 125, 80 MVar reactor bank shall be suitable for bay width of the substation/s, as indicated in the attached schedule – A of the tender.

If the reactor is intended to be used as Line reactor then NGR and SA shall be supplied as per technical specification. However, if it intended to be used as Bay reactor, then NGR and SA shall not be supplied.

Each reactor shall be supplied with Fiber optic sensors, Nitrogen Injection System for Protection against the Fire & Explosion as per specification no. GETCO/E/TS-FF/2902 DTD.JUNE 2008, attached with this specification. However, Bidder has to quote the requirement of equipment / Material as indicated in Schedule-A of commercial Bid.

1.2.0 CLIMATIC AND ISOACERAUNIC CONDITIONS:

1.2.1 The climatic conditions at site under which the equipment shall operate satisfactory are as under:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Altitude above main sea level (Meters)</td>
<td>Not exceeding 1000 mtrs.</td>
</tr>
<tr>
<td>ii</td>
<td>Max. ambient air temperature °C</td>
<td>50°C</td>
</tr>
<tr>
<td>iii</td>
<td>Max. daily average ambient</td>
<td>35°C</td>
</tr>
<tr>
<td>iv</td>
<td>Relative humidity for design of equipment %</td>
<td>95%</td>
</tr>
<tr>
<td>v</td>
<td>Max. yearly weighted average temperature °C</td>
<td>30°C</td>
</tr>
<tr>
<td>vi</td>
<td>Minimum temperature of air in shade °C</td>
<td>3.5°C</td>
</tr>
<tr>
<td>vii</td>
<td>Climate</td>
<td>Moderately hot and humid tropical climate conductive to rust and fungus growth</td>
</tr>
<tr>
<td>viii</td>
<td>Maximum annual rain fall in min</td>
<td>1150mm during June to October</td>
</tr>
<tr>
<td>ix</td>
<td>Isoceraunic level</td>
<td>30</td>
</tr>
<tr>
<td>x</td>
<td>Average number of thunder storm days/annum</td>
<td>15</td>
</tr>
<tr>
<td>xi</td>
<td>Maximum wind pressure Kg/m2</td>
<td>150</td>
</tr>
<tr>
<td>xii</td>
<td>Earthquake acceleration (G)</td>
<td>0.08x2 g.</td>
</tr>
</tbody>
</table>
1.2.2 All electrical devices shall be given tropical and fungicidal treatment and shall be capable of satisfactory operation under the severe climatic conditions that would prevail at site as described above.

1.2.3 The equipment offered shall be suitable for continuous operation under above conditions at the full rated capacity.

1.2.4 Since the sub-stations, where the equipment is to be installed, is on the coastal and/or industrial areas, the equipment offered shall be suitable for heavily polluted atmosphere.

1.2.5 The equipment offered shall be suitable for hot line maintenance techniques.

1.3.0 SYSTEM PARTICULARS:

1.3.1 Nominal System Voltage 400 kV rms.

1.3.2 Highest System Voltage 420 kV rms.

1.3.3 System Frequency 50 Hz.

1.3.4 Number of Phases Three (3)

1.3.5 Neutral Directly earthed

1.4.0 AUXILIARY POWER SUPPLY:

1.4.1 Auxiliary electrical equipment shall be suitable for operation on the following supply system.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Voltage Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Power devices (like drive motors etc.)</td>
<td>415 Volts, 3 phase, 4 wire, 50 Hz. Neutral grounded AC supply.</td>
</tr>
<tr>
<td>ii</td>
<td>AC control and protective devices, lighting fixtures, space heaters, f.h.p. motors etc.</td>
<td>240 Volts, 1 phase, 2 wire, 50 Hz, AC supply with one lead grounded.</td>
</tr>
<tr>
<td>iii</td>
<td>D.C. alarm control and protective device</td>
<td>Two separate 220 Volts, two wires ungrounded D.C. supply from battery.</td>
</tr>
<tr>
<td>iv</td>
<td>Solid state control</td>
<td>48-V DC supply from battery</td>
</tr>
</tbody>
</table>

1.4.2 The above supply voltages may vary as follows:

All devices shall be suitable for continuous operation over entire range of voltage.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Voltage Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>AC supply</td>
<td>Voltage variation ± 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frequency variation ± 3%</td>
</tr>
<tr>
<td>ii</td>
<td>DC supply</td>
<td>(-) 15% to (+) 10% variation.</td>
</tr>
</tbody>
</table>
1.4.3. Each of the foregoing supplies will be made available by the purchaser at one terminal point for each reactor for operation of accessories and auxiliary equipment.

1.4.4. 110-V, 1-Ø AC supply will not be provided by the Purchaser. To obtain 110-V supply from purchaser’s 415-V, 3-Ø, 3-W supply, the contractor shall incorporate 415/110-V single phase dry type control transformer with ± 10% off-circuit voltage, taps on 415 volts side with switches and fuses on both the primary and secondary sides, with one end of secondary earthed.

1.5.0. LOCATION OF THE EQUIPMENT:

The location of Shunt Reactors will be any where in the State of Gujarat.

1.6.0. SPECIFIC TECHNICAL PARTICULARS OF THE EQUIPMENT:

The Shunt Reactor bank shall comply with the following technical requirements:

1.6.1. SHUNT REACTOR:

<table>
<thead>
<tr>
<th>i)</th>
<th>Rated voltage</th>
<th>420 kV 1.0 (p.u.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii)</td>
<td>Rated reactive power</td>
<td>3 phase 50 / 63 MVAr OR Single phase (3x16.67 MVAr) / 63 (3x21) MVAr</td>
</tr>
<tr>
<td>iii)</td>
<td>Rated reactive power</td>
<td>3 phase 80 / 125 MVAr OR Single phase (3x26.67 MVAr) / (3X41.67) MVAr</td>
</tr>
<tr>
<td>iv)</td>
<td>Rated Frequency</td>
<td>50 Hz.</td>
</tr>
<tr>
<td>v)</td>
<td>No. of phases</td>
<td>3 phases</td>
</tr>
<tr>
<td>vi)</td>
<td>System fault level</td>
<td>40 kA</td>
</tr>
<tr>
<td>vii)</td>
<td>Connection</td>
<td>Star with neutral brought out.</td>
</tr>
<tr>
<td>viii)</td>
<td>Duration of short circuit current</td>
<td>3 sec.</td>
</tr>
<tr>
<td>ix)</td>
<td>INSULATION LEVEL FOR WINDING</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Lighting Impulse 1.2/50 micro seconds withstand voltage</td>
<td>1300 kV Peak</td>
</tr>
<tr>
<td>b)</td>
<td>Switching surge withstand voltage</td>
<td>1050 kV Peak</td>
</tr>
<tr>
<td>c)</td>
<td>One minute power Frequency withstand Voltage</td>
<td>630 kV rms.</td>
</tr>
<tr>
<td>vi)</td>
<td>Maximum admissible temp. Rise over an ambient temp. of 50° and at highest voltage:</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>of winding by resistance</td>
<td>55°C</td>
</tr>
<tr>
<td>b)</td>
<td>of top oil by thermometer</td>
<td>50°C</td>
</tr>
<tr>
<td>c)</td>
<td>The temperature of the hottest spot</td>
<td>As per relevant standard.</td>
</tr>
<tr>
<td>ix)</td>
<td>Cooling system</td>
<td>Natural oil circulation (ONAN)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>x)</td>
<td>Total loss at rated voltage and frequency as a percentage of rated MVAR</td>
<td>Not exceeding 0.5%</td>
</tr>
<tr>
<td>xi)</td>
<td>Insulation level of Neutral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Impulse with-stand voltage</td>
<td>550 kV peak</td>
</tr>
<tr>
<td></td>
<td>b) P. F withstand voltage</td>
<td>230 kV rms.</td>
</tr>
<tr>
<td></td>
<td>c) Whether neutral is to be brought out</td>
<td>Yes (Through adequately Rated 145 kV class oil filled condenser bushings)</td>
</tr>
<tr>
<td>xii)</td>
<td>Terminals:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Line Terminals</td>
<td>420 kV oil filled condenser bussing with test taps</td>
</tr>
<tr>
<td></td>
<td>b) Neutral Terminals</td>
<td>Adequately rated bushings</td>
</tr>
<tr>
<td>xiii)</td>
<td>Impedance ratio (X0/X1)</td>
<td>Between 0.9 and 1.0 (The bidder must clearly specify the exact figure).</td>
</tr>
<tr>
<td>xiv)</td>
<td>Range of constant impedance</td>
<td>Up to 1.5 p.u. voltage. (The bidder shall furnish complete saturation characteristics of the Reactors up to 2.5 p.u. voltages).</td>
</tr>
<tr>
<td>xv)</td>
<td>Tolerance on current at rated voltage</td>
<td>0 to +5% of rated current</td>
</tr>
<tr>
<td>xvi)</td>
<td>Harmonic content in phase current</td>
<td>The crest value of the third Harmonic component in phase current not to exceed 3% of the crest value of fundamental when reactor is energized at rated voltage with sinusoidal wave form.</td>
</tr>
<tr>
<td>xvii)</td>
<td>Permissible current unbalance among different phases.</td>
<td>+ 2% of the average value</td>
</tr>
<tr>
<td>xviii)</td>
<td>Minimum clearance in air at rated voltage of with terminal connector</td>
<td>Phase to Phase:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>420 kV</td>
<td>4000 mm</td>
</tr>
<tr>
<td></td>
<td>145 kV</td>
<td>1430 mm</td>
</tr>
<tr>
<td>xix)</td>
<td>Noise level at rated voltage and frequency</td>
<td>As per NEMA –TR-I</td>
</tr>
<tr>
<td>xx)</td>
<td>Bushings:</td>
<td>Line side</td>
</tr>
<tr>
<td></td>
<td>a) Rated voltage</td>
<td>420 kV</td>
</tr>
<tr>
<td></td>
<td>b) Creepage distance (total)</td>
<td>10,500 mm</td>
</tr>
<tr>
<td></td>
<td>c) Mounting</td>
<td>Tank cover (Straight line formation).</td>
</tr>
<tr>
<td>d)</td>
<td>1.2/50 micro sec. lightning impulse withstand voltage (kVp)</td>
<td>1425</td>
</tr>
<tr>
<td>e)</td>
<td>Switching impulse (250/2500 micro seconds) withstand voltage (kVp)</td>
<td>1050</td>
</tr>
<tr>
<td>f)</td>
<td>One min PF withstand voltage</td>
<td>630 kV rms</td>
</tr>
<tr>
<td>g)</td>
<td>Rated current (A)</td>
<td>800</td>
</tr>
</tbody>
</table>
| xxi) | Vibration level | Not more than 200 microns peak to peak. Average vibrations (Peak to peak) shall 60 microns. Tank stress shall not exceed 2.0 kg/mm² at any point on the tank.
### 1.6.2 NEUTRAL GROUNDING REACTOR:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Rated voltage from insulation strength considerations</td>
</tr>
<tr>
<td>ii)</td>
<td>Rated frequency</td>
</tr>
<tr>
<td>iii)</td>
<td>No of phases</td>
</tr>
<tr>
<td>iv)</td>
<td>Type</td>
</tr>
<tr>
<td>v)</td>
<td>Insulation</td>
</tr>
<tr>
<td>vi)</td>
<td>Max. continuous current</td>
</tr>
<tr>
<td>vii)</td>
<td>Rated short time current (10 sec)</td>
</tr>
<tr>
<td>viii)</td>
<td>Rated impedance at rated short time current</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Line side</th>
<th>Ground side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bushings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Rated voltage</td>
<td>145 kV</td>
</tr>
<tr>
<td>ii)</td>
<td>Creepage distance (total) in mm</td>
<td>3625</td>
</tr>
<tr>
<td>iii)</td>
<td>Mounting</td>
<td>Tank cover</td>
</tr>
<tr>
<td>iv)</td>
<td>Lightning Impulse (1.2/50 micro sec) withstand voltage (kVp)</td>
<td>650</td>
</tr>
<tr>
<td>v)</td>
<td>Power Frequency withstand voltage (kV rms)</td>
<td>275</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Line side</th>
<th>Ground side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection</td>
<td></td>
<td>Between neutral of shunt reactor and ground</td>
</tr>
<tr>
<td>Insulation level for winding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Lightning Impulse (1.2/50 micro sec) withstand voltage (kVp)</td>
<td>550</td>
</tr>
<tr>
<td>ii)</td>
<td>Power Frequency withstand voltage (kV rms)</td>
<td>230</td>
</tr>
<tr>
<td>iii)</td>
<td>Max. admissible temperature rise over ambient temperature of 50ºC at rated voltage a) of winding measured by resistance</td>
<td>50 ºC</td>
</tr>
<tr>
<td></td>
<td>b) of top oil measured by thermometer</td>
<td>45 ºC</td>
</tr>
<tr>
<td>iv)</td>
<td>Cooling system</td>
<td>Natural oil cooling (ONAN)</td>
</tr>
<tr>
<td>v)</td>
<td>Cooling medium</td>
<td>Mineral oil</td>
</tr>
<tr>
<td>vi)</td>
<td>Whether neutral is to be brought out</td>
<td>Yes, through 24 kV class porcelain bushing.</td>
</tr>
<tr>
<td>vii)</td>
<td>Method of grounding</td>
<td>Solidly connected between neutral of shunt reactor and earth.</td>
</tr>
</tbody>
</table>
### 1.6.2. BUSHING CURRENT TRANSFORMERS:
Shunt Reactor (on each phase connection)

<table>
<thead>
<tr>
<th></th>
<th>Line side</th>
<th>Neutral side</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a) Ratio</strong></td>
<td>Core 1: 200/1A 200/1A</td>
<td>Core 2: 2000-1000-500/1A</td>
</tr>
<tr>
<td></td>
<td>Core 2: 200/1A</td>
<td>Core 3: - do -</td>
</tr>
<tr>
<td></td>
<td>Core 4: 200/1A Suitable for W.T.I.</td>
<td></td>
</tr>
<tr>
<td><strong>b) Minimum Knee point voltage or burden and accuracy class</strong></td>
<td>Core 1: ≥200V Class PS ≥200V Class PS</td>
<td>Core 2: ≥2000V Class PS ≥200V Class PS</td>
</tr>
<tr>
<td></td>
<td>Core 2: ≥200V Class PS ≥2000V Class PS</td>
<td>Core 3: ≥2000V Class PS ≥200V Class PS</td>
</tr>
<tr>
<td></td>
<td>Core 4: 10 VA Class- 0.5 Suitable for W.T.I. being supplied</td>
<td>Core 4: --</td>
</tr>
<tr>
<td><strong>c) Maximum CT Resistance / current</strong></td>
<td>Core 1: 1 ohm ≤30 mA at Vk/2 1 ohm ≤30 mA at Vk/2</td>
<td>Core 2: 10 - 5 - 2.5 ohms. ≤30 mA at Vk/2</td>
</tr>
<tr>
<td></td>
<td>Core 2: 1 ohm ≤30 mA at Vk/2 10 - 5 - 2.5 ohms. ≤30 mA at Vk/2</td>
<td>Core 3: 10 - 5 - 2.5 ohms. ≤30 mA at Vk/2</td>
</tr>
<tr>
<td></td>
<td>Core 3: 1 ohm ≤30 mA at Vk/2 10 - 5 - 2.5 ohms. ≤30 mA at Vk/2</td>
<td>Core 4: --</td>
</tr>
<tr>
<td><strong>d) Application</strong></td>
<td>Core 1: Reactor Differential Reactor Differential</td>
<td>Core 2: Restricted earth Spare / (Line protection Main- II/ Tzone differential protn.</td>
</tr>
<tr>
<td></td>
<td>Core 3: Reactor back up Spare / (Line protection Main- II/ Tzone differential protn.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Core 4: Metering            Temp. Indicator (on one phase only)</td>
<td></td>
</tr>
</tbody>
</table>

**Neutral Grounding Reactor:**

<table>
<thead>
<tr>
<th></th>
<th>Line side</th>
<th>Neutral side</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a) Ratio</strong></td>
<td>Core 1: 200/1A</td>
<td>Core 2: 200/1A</td>
</tr>
<tr>
<td><strong>b) Min knee point voltage &amp; accuracy class</strong></td>
<td>Core 1: ≥200V Class PS ≥200V Class PS</td>
<td>Core 2: ≥2000V Class PS ≥200V Class PS</td>
</tr>
<tr>
<td></td>
<td>Core 1: ≥200V Class PS ≥200V Class PS</td>
<td>Core 2: ≥2000V Class PS ≥200V Class PS</td>
</tr>
<tr>
<td><strong>c) Maximum CT Resistance/current</strong></td>
<td>Core 1: 1 ohm ≤30 mA at Vk/2 1 ohm ≤30 mA at Vk/2</td>
<td>Core 2: 10 - 5 - 2.5 ohms. ≤30 mA at Vk/2</td>
</tr>
<tr>
<td></td>
<td>Core 2: 1 ohm ≤30 mA at Vk/2 10 - 5 - 2.5 ohms. ≤30 mA at Vk/2</td>
<td>Core 3: 10 - 5 - 2.5 ohms. ≤30 mA at Vk/2</td>
</tr>
<tr>
<td><strong>d) Application</strong></td>
<td>Core 1: Restricted Earth fault Restricted Earth fault</td>
<td>Core 2: Restricted Earth fault</td>
</tr>
</tbody>
</table>

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NOTE:

1. CT shall be as per IS: 2705 (latest amended)
2. It shall be possible to remove the CTs from the reactor tank without removing the reactor cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.
3. CT Secondary leads shall be brought out to a weather proof terminal box near the bushings. These terminals shall be wired out to cooler control cabinet/ marshalling box using separate cables for each core.
4. CT characteristics shall be subject to the purchaser's approval.
5. Magnetization current of CTs shall be < or = 30 mA at highest tap.
6. The arrangement of current transformer on shunt reactor / NGR shall be as per drawing no. GETCO/E/4S-001/039A.
7. The secondary excitation current of class PS shall not be more than 4% of rated secondary current at 25 % of knee point voltage.
8. Class (for relevant protection and duties) as per IEC: 60185.

1.6.3 GAPLESS SURGE ARRESTER:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Rated arrester voltage</td>
<td>120 kV</td>
</tr>
<tr>
<td>ii)</td>
<td>Rated system voltage</td>
<td>145 kV</td>
</tr>
<tr>
<td>iii)</td>
<td>Rated system frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>iv)</td>
<td>System neutral earthing</td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>v)</td>
<td>Installation</td>
<td>Outdoor</td>
</tr>
<tr>
<td>vi)</td>
<td>Nominal discharge current</td>
<td>10 kA of 8/20 micro sec wave</td>
</tr>
<tr>
<td>vii)</td>
<td>Class of arrester</td>
<td>10 kA heavy duty type</td>
</tr>
<tr>
<td>viii)</td>
<td>Minimum discharge capacity</td>
<td>8 kJ/kV (referred to rated voltage)</td>
</tr>
</tbody>
</table>
(ix)| Continuous operating voltage at 50 ºC | 102 kV                       |
<p>|x)| Maximum switching surge residual voltage | 280 kVp                      |
|xi)| Maximum residual voltage at a) 5 kA | 320 kVp                      |
|   | b) 10 kA nominal discharge current | 340 kVp                      |
|xii)| Long duration discharge current class | 3 (three)                     |
|xiii)| High current short duration test value (4/10 micro sec. wave) | 100 kAp                      |
|xiv)| Current for pressure relief test  | 40 kA rms                    |
|xv)| Low current long duration test value (2000 micro sec) | 1000 Apeak                   |
|xvi)| Minimum total creepage distance   | 3625 mm                      |
|xvii)| One minute power frequency withstand voltage of arrester housing | 275 kV rms                   |
|xviii)| Impulse withstand voltage of arrester housing with 1.2/50 micro sec wave | +650 kVp                      |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>xix)</td>
<td>Pressure relief class</td>
</tr>
<tr>
<td>xx)</td>
<td>RIV at 92 kV rms</td>
</tr>
<tr>
<td>xxi)</td>
<td>Partial discharge at 1.05 continuous over voltage</td>
</tr>
<tr>
<td>xxii)</td>
<td>Seismic acceleration</td>
</tr>
<tr>
<td>xxiii)</td>
<td>Reference ambient temperature</td>
</tr>
<tr>
<td>xxiv)</td>
<td>Max. Continuous Operating Voltages</td>
</tr>
<tr>
<td>xxv)</td>
<td>Anticipated levels of temporary over voltage and its duration</td>
</tr>
<tr>
<td>xxvi)</td>
<td>Ratio of switching impulse residual voltage to rated voltage of arrester</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>xx)</td>
<td>Less than 500 micro volts</td>
</tr>
<tr>
<td>xxi)</td>
<td>Not more than 50 pC</td>
</tr>
<tr>
<td>xxii)</td>
<td>0.3 g horizontal</td>
</tr>
<tr>
<td>xxiii)</td>
<td>50°C</td>
</tr>
<tr>
<td>xxiv)</td>
<td>As per IEC 60099-4 cl.3.2.1</td>
</tr>
<tr>
<td>xxv)</td>
<td>1.3 times rated voltage of arrester 1 to 10 sec</td>
</tr>
<tr>
<td>xxvi)</td>
<td>Not more than two</td>
</tr>
</tbody>
</table>

1.7.0. **OTHER REQUIREMENTS:**

1.7.1. Shunt Reactor shall be connected to the 400 kV systems for reactive load compensation and it shall be capable of controlling the dynamic over voltage occurring in the system due to load rejection.

1.7.2. Shunt Reactor shall be capable of operating continuously at a voltage 5% higher than rated voltage of shunt reactor without injurious heating.

1.7.3. Temperature rise shall be guaranteed when reactor is operating at 420 kV (Highest voltage of system).

1.7.4. The Reactor shall be subjected to switching surge over voltage up to 2.5 p.u. and temporary over voltage for few cycles, of the order of 2.3 p.u., followed by power frequency over voltage up to 1.5 p.u. The reactor must withstand the stresses due to above transient dynamic conditions which may cause additional current flow as a result of changed saturation characteristics / slope beyond 1.5 p.u.

1.7.5. The bidder shall clearly guarantee in his bid that the equipment offered shall perform satisfactorily under both the power frequency and switching such over voltages shall not cause any damage to the winding or withstanding Thermal and mechanical effects of short circuit at the terminals for a duration of 3 seconds without any damage of distortion.

1.7.6. The neutral grounding reactors are required for grounding of the neutral point of shunt reactors to limit the secondary arc current and the recovery voltage to a minimum value.
SECTION - II

GENERAL TECHNICAL REQUIREMENTS

2.1.0. SCOPE:

2.1.1. This scope covers design manufacture, assembly, inspection and testing at manufacturer’s works, supply, delivery including loading, transportation & unloading on plinth at site of 420 kV shut reactors, NGR & SA and accessories required for the safe, efficient, satisfactory and trouble free operation of the equipment. Also, at the discretion of the purchaser, the seller may have to undertake erection, supervision of erection, testing and commissioning of the equipment included in his scope of supply. Bidder shall quote for these items as required in the price schedule.

2.1.2 The scope of work shall also include EITHER complete erection, testing and commissioning of all the equipments/accessories furnished under this specification OR only supervision of erection, testing and commissioning of all the equipment furnished under this Specification, as indicated in Schedule – A of the commercial bid.

2.1.3 It is not the intent to specify completely herein all the details of design and construction of the equipment. However, the equipment shall confirm, in all respect to high standards of engineering, design and workmanship and be capable of performing in continuous commercial operation up to guarantee in a manner acceptable to the purchaser, who will interpret the meaning of drawings and specifications and shall have the power to reject any work or material which in his opinion are not in full accordance therewith.

2.1.3 All deviations from this specification shall be separately listed in specified Schedule, in the absence of which, it will be presumed that the provision of the specification are complied with by the bidder.

2.2.0. STANDARDS:

2.2.1. All equipments provided under this specification, shall, in General conform to the latest issued including amendments of the following standards.

<table>
<thead>
<tr>
<th>Indian Standards</th>
<th>Title</th>
<th>International &amp; Internationally recognized</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS-2026</td>
<td>Power Transformers</td>
<td>IEC Publication 76</td>
</tr>
<tr>
<td>IS-3639</td>
<td>Fitting and Accessories for power transformers</td>
<td>IEC - 289</td>
</tr>
<tr>
<td>IS-5553 Part-I</td>
<td>Shunt Reactors</td>
<td>IEC - 289</td>
</tr>
<tr>
<td>IS-335</td>
<td>Insulating oil for Transformers and switchgears</td>
<td>IEC – 296 -2000</td>
</tr>
<tr>
<td>IS - 2009</td>
<td>Bushings for alternating voltage above 1000 Volts.</td>
<td>IEC - Document 36 A II Revision of Publication 137</td>
</tr>
<tr>
<td>IS - 2705</td>
<td>Current Transformers</td>
<td>IEC Publication 185</td>
</tr>
<tr>
<td>IS - 2147</td>
<td>Degree of protection provided by enclosures for low voltage switchgear and control.</td>
<td></td>
</tr>
<tr>
<td>IS - 5</td>
<td>Colour of ready mix paints</td>
<td></td>
</tr>
<tr>
<td>IS - 375</td>
<td>Internal wiring of Marshalling box.</td>
<td></td>
</tr>
</tbody>
</table>

2.2.2. In case equipment conforms to other internationally acceptable standards which ensure equivalent or better performance than that specified under clause 2.2.0 then English version of such standards or relevant extracts of the same shall be forwarded with the bid and the salient features of comparison shall be brought out separately in the bid.

2.2.3. Accessories, components, parts and raw materials shall conform to relevant Indian standards.

2.3.0. **DRAWINGS AND DATA:**

2.3.1. Drawings in AutoCAD format and in hard copy, incorporating the following particulars shall be submitted by the bidder with the bid.

i) General outline drawings showing dimensions, net and shipping weight of the equipment offered.
ii) Outline drawing showing plan, front and side elevation with all fittings and accessories.
iii) Drawings for foundation.
iv) Schematic wiring diagram of control cabinet.
v) Marshalling box with wiring diagram.
vi) Drawings of all types of bushings indicating plan, elevation, terminal details, mounting details, make and type, current and voltage rating, creepage distances and main characteristics.
vii) Type test reports and oscillogram of similar equipment. The type test reports shall be from reputed laboratory / Government institution.
viii) Rating and diagram plate.

2.3.2. The bidder may furnish any other drawings which he considers necessary for giving complete information about his equipment.

2.3.3. After receipt of an order, the successful bidder shall have to furnish, the following drawings in hard as well as AutoCAD format, for approval of the purchaser.

i) General outline drawing showing front, side elevations and plan of the reactor and accessories with detailed dimensions.
ii) Detailed foundation drawing.
iii) Drawings of each type of bushings, lifting dimensions, clearances between terminals and ground, quantity of insulating oil, name plate details etc.
iv) Large scale drawing of the winding indicating arrangement of terminal connections.
v) Control and wiring diagrams and drawings showing temperature indicator, alarm circuits etc.

vi) Drawings showing Construction and mounting details of marshalling box / boxes.

vii) Detailed drawing showing wheel loading and its centre of gravity.

viii) Detailed operation and maintenance guide.

ix) Layout for mounting details of shunt reactor.

x) Rating and diagram plate.

2.3.4. After receipt of the order, the successful bidder shall prepare a program for submission of various drawings for the approval of the purchaser within commencement period.

2.3.5. Drawings, diagrams, instructions and reports shall be identified by descriptive title indicating their application to the equipment offered. All drawings and data shall be annotated in English Language; Dimensions shall be in Metric system.

2.3.6. The bidder may submit any other drawings found necessary in addition to the drawings mentioned above or as asked during detailed engineering.

2.4.0. GENERAL CONSTRUCTION DETAILS:

Tank and Tank accessories.

2.4.1. **Tank:**

a) Tank shall be welded construction and fabricated from tested quality low carbon steel of adequate thickness.

b) All seems and those joints not required to be opened at site shall be factory welded and wherever possible they shall be double welded. All welding shall be either stress relieved or radio graphically tested.

c) Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

d) The tank shall be designed to withstand:
   i) Mechanical shocks during transportation.
   ii) Vacuum filling of oil.
   iii) Continuous internal pressure of 0.35 kg/cm² over normal hydrostatic pressures of oil.
   iv) Short circuit forces.

e) Wherever possible the reactor tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe.
f) Tank shields shall be such that no magnetic field shall exist outside the tank. They shall be of magnetically permeable material. If required impermeable shields shall be provided at the coil ends. Tank shields shall not resonate when excited at the natural frequency of the Reactor.

g) The base of each tank shall be so designed that it shall be possible to move the complete reactor unit by skidding in any direction without injury when using plates or rails.

h) Each tank shall be provided with
   i) Lifting lugs suitable for lifting the Reactor complete with oil.
   ii) A minimum of four jacking pads, in accessible position to enable the Reactor complete with oil, to be raised or lowered using mechanical screw jacks.
   iii) Suitable haulage holes shall be provided.
   iv) A valve of other suitable means shall be providing to fix the on line dissolved Gas monitoring system to facilitate continuous dissolved gas analysis. Location and size of the same shall be finalized during detailed engineering

i) Adequate space shall be provided at the bottom of the tank for collection of sediments.

j) Suitable guides shall be provided in this tank for positioning of the core and coil assembly.

2.4.2. **Tank Cover:**

a) The tank cover shall be of adequate strength and shall not distort when lifted. It shall be slightly sloped to prevent retention of water.

b) At least two adequately sized inspection opening, one at each end of the tank, shall be provided for easy access to bushings and testing of earth connections. The inspection covers shall not weigh more than 25 KGs.

c) The tank cover shall be fitted with pockets at the position of maximum oil temperature at MCR for bulbs of oil and winding temperature indicator. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer pocket shall be fitted with a captive screwed top to prevent the ingress of water. The tank wall penetrations shall be leak proof, suitably marked with respective sensor identification.

d) Bushing, turrets, covers of inspection opening, thermometer pocket etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.
2.4.3. **Axles and wheels:**

a) Reactors are to be provided with flanged bi-directional wheels and axles. These shall be so designed that under any service condition they shall not deflect sufficiently to interfere with the movement of the reactor.

b) Suitable locking arrangement shall be provided for the wheels to prevent accidental movement of the reactor.

c) The wheels are required to swivel and they shall be arranged so that they can be turned through an angle of 90° when the tank is jacked up to clear of rails. Means shall be provided for locking the swivel movements in positions parallel to and at right angles to the longitudinal axis of the tank.

d) Flanged wheels provided shall be suitable for use on rail track gauge of 1676 mm in longitudinal and transverse direction.

e) The reactor shall be suitable for mounting on concrete plinth foundation directly. The wheels and axles shall be suitable for fixing to the under carriage of Shunt Reactor to facilitate movements of shunt reactor on Rail track.

2.4.4. **Conservator Tank:**

a) The Conservator tank shall have adequate capacity between highest and lowest visible levels to meet the requirement of expansion of the total cold oil volume in the Reactors and cooling equipment from minimum ambient temperature to 90°C.

b) One end of the conservator shall be bolted in position so that it can be removed for cleaning purpose.

c) Conservator shall be provided in such a position as not to obstruct the electrical connections to the Reactor.

d) The Conservator shall be fitted with magnetic oil level gauge with low level electrically insulated alarm contact.

e) **NGR shall have conventional type conservator with prismatic oil level gauge.**

2.4.5. **Oil Preservation Equipment:**
Air cell type conservator tank is to be provided for oil conservator system. Bidder shall offer diaphragm type oil sealing in conservator to prevent oxidation and contamination of oil due to contact with water. *In this type of oil preservation system, conservator shall be fitted with a dehydrating filter breather.* The requirements of the systems are given below:

a) Diaphragm Seal type constant oil pressure system. It shall be so designed that:

i) Contact of the oil with atmosphere is prohibited by using a flexible urethane air cell.

ii) The cell is vented to the atmosphere through a dehydrator air breather and inflates or deflates as the oil volume changes due to changes in temperature.

iii) The connection of the air-cell to the top of reservoir is by an air-proof seal permitting entrance of air into the cell only.

iv) Diaphragm used shall be suitable for continuous operation in an atmosphere of 100°C to which transformer oil is likely to rise.

v) The diaphragm of the conservator shall withstand the vacuum during installation and maintenance. Otherwise provision shall be made to isolate the conservator from main tank during vacuum by providing vacuum sealing valve in the pipe connecting the main tank with the conservator.

b) Dehydrating filter breather

Each conservator shall be fitted with a dehydrating filter breather. It shall be so designed that:

i) Passage of air is through a dust filter and silica gel.

ii) Silica gel is isolated from atmosphere by an oil seal.

iii) Moisture absorption is indicated by change in colour of the tinted crystals which can be easily observed from a distance.

iv) Breather is mounted not more than 1400mm above rail top level.

v) It is of clear view type design so that moisture absorption indication by change in colour of silica gel is visible from a distance.

vi) Size of breather shall be such that it content 5 kG of silica gel in it.

vii) The nos. of breathers shall be Three or more as required for main conservator, Two for OLTC conservator and TWO for NGR tank conservator.

2.4.6 Pressure Relief Device:

The pressure relief device provided shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage of the equipment. The devices shall operate at a
static pressure less than the hydraulic test pressure of reactor tank. The pressure relief device shall be of spring loaded type with alarm contacts.

2.4.7 Earthing Terminals:

Two earthing terminals shall be provided at positions close to each of the two bottom corners of tank. These grounding terminals should be suitable to receive Purchaser's grounding conductor / strips shall be 80 x 10mm G.I. flats. Adequately rated pin insulators mounted on the tank shall be provided for grounding the neutral terminals.

2.4.8 Anti Earth Quake Clamping Device:

To prevent Reactor movement during earthquake, a clamping device should be provided for fixing the reactor to the foundation. The contractor shall supply necessary bolts for embedding in the concreting after reactor is placed on foundation. The arrangement shall be such that the Reactor can be fixed to or unfastened from these bolts as desired.

2.4.9 Buchholz Relay:

a) A double float type Buchholz Relay shall be provided. All gases evolved in the reactor shall collect in this relay. The Relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. A copper tube shall be connected from the gas collector to a valve located about 1200mm above ground level to facilitate sampling with the reactor in service. The device shall be provided with two electrically independent contacts. One for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

b) A sudden pressure Relay shall be fitted on main tank to operate on rate of rise of pressure. An Electrically insulated trip contact shall be provided in sudden pressure relay.

2.5.0 CORE:

a) The Shunt Reactor shall be either gapped core type or magnetically shielded air core type construction. The bidder shall describe in details (with calculation and reference) the merits and demerits of the type offered.

b) In case gapped core construction the following requirements are stipulated.

i) The core shall be constructed from high grade, non-ageing, cold rolled, grain oriented silicon steel laminations of prime quality only.

ii) 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 components
at right angles to the plane of laminations which may cause local heating.

iii) 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.

iv) Cores and windings shall be capable of withstanding shocks during transport, installation and services. Adequate provisions shall be made to prevent movement of core and winding relative to tank during these conditions.

v) The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of the tank through drain valve. The design of the core assembly shall be such that it will not cause trapping of air during oil fillings.

vi) All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

vii) When bell type tank construction is offered suitable projecting guides shall be provided on core assembly to facilitate removal of tank.

c) In case of core-less construction there shall be:

i) A magnetic shields around the coreless coils.

ii) Non-magnetic material sheets shall form the central core to minimize the vibrations.

2.6.0. WINDINGS:

a) The conductors shall be electrolytic grade copper, free from scales and burrs.

b) The insulation of Reactor windings and connection shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and these should remain non-catalytic and chemically inert in oil during service.

c) Coils shall be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

d) The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperature along the windings.

e) Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spots of the windings.

f) The 400 kV windings shall be done in dust free and conditioned atmosphere.

g) Fiber optic sensors shall be embedded in each phase of the winding located where the temperature is highest. The
location and details shall be indicated in the respective drawings.

h) The insulation paper shall be of high quality and the value of degree of polymerization shall not be less than 1200 \( \text{Pv} \) and the necessary test certificate shall be submitted along with the stage inspection report. Provision shall be made for taking sample of paper for testing purpose and location shall be easily accessible and indicated on the transformer tank by affixing special caution plate.

2.7.0. **INSULATING OIL**

2.7.1 The oil for first filling together with 10% extra shall be supplied with each transformer. The oil shall comply in all respects with the provisions of the latest edition of IS: 335 & **IEC: 60296-2000** (as amended up to date). Particular attention shall be paid to deliver the oil free from moisture having uniform quality throughout. The oil may be supplied either in sealed tanker, or in non-returnable sealed steel drums, which will be opened at site in presence of GETCO representative. The quantity of oil for first filling & 10% extra shall be stated in the tender.

The supplier of reactor shall furnish test certificates of the insulating power oil supplied against their acceptance norms, prior to dispatch. Subsequently oil samples shall be drawn

i) at manufacturer’s works before and after heat run test and shall be tested for following:
   a) BDV in kVrms
   b) Moisture content
   c) Dissolved Gas Analysis – samples for DGA shall be taken from sampling device within 24 hrs prior to commencement of heat run test and immediately after this test. The acceptance norms shall be as per IS:10593 (based on IEC-599)

ii) prior to filling in main tank at site and shall be tested for BDV and moisture content for acceptance norms as per Appendix – A.

iii) prior to energisation at site and shall be tested for the following:
    a) BDV in kVrms
    b) Moisture content
    c) Tan Delta at 90 deg cen.
    d) Resistivity at 90 deg cen.
    e) Interfacial Tension

iv) The contractor shall dispatch the reactor filled with oil or in an atmosphere of Nitrogen. The bidder shall take care of the weight limitation on transport and handling facility at site. Necessary arrangement shall be ensured by the bidder to take care of pressure drop of nitrogen 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.

v) The contractor shall warrant that oil supplied is in accordance with the following specification.
## APPENDIX – A

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Characteristics of Transformer Oil</th>
<th>Requirement</th>
<th>Method of test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Appearance</td>
<td>The oil shall be clear transparent &amp; free from suspended matter of sediments.</td>
<td>A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature.</td>
</tr>
<tr>
<td>2</td>
<td>Density, Max.</td>
<td>0.89 gm/Cm³ at 29.5 °C</td>
<td>IS: 1448</td>
</tr>
<tr>
<td>3</td>
<td>Dynamitic Viscosity CST at 27 °C</td>
<td>27 cSt (Max.)</td>
<td>IS: 1448</td>
</tr>
<tr>
<td>4</td>
<td>Flash point penskey-Marten (Closed)</td>
<td>140 °C Min.</td>
<td>IS: 1448</td>
</tr>
<tr>
<td>5</td>
<td>Interfacial tension at 27 °C Newton/M</td>
<td>0.04 Min.</td>
<td>IS: 6104</td>
</tr>
<tr>
<td>6</td>
<td>Pour point</td>
<td>-15 °C (Max.)</td>
<td>IS: 1448</td>
</tr>
<tr>
<td>7</td>
<td>Neutralization value</td>
<td></td>
<td>IS: 335</td>
</tr>
<tr>
<td></td>
<td>a) (Total acidity) mg. (Max)</td>
<td>0.03 mg KOH/gm Max.</td>
<td>Appendix-A</td>
</tr>
<tr>
<td></td>
<td>b) Inorganic Acidity/alkalinity</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Corrosive Sulphur</td>
<td>Non corrosive</td>
<td>ASTM D1275 subjecting oil 150°C for 48 hrs.</td>
</tr>
<tr>
<td></td>
<td>(In terms of classification of copper strips) 48 Hrs. @ 150 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Electric Strength</td>
<td></td>
<td>IS: 6792</td>
</tr>
<tr>
<td></td>
<td>(Break down voltage)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) New Untreated Oil</td>
<td>30 KV Min. (rms)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) After treatment</td>
<td>60 KV Min. (rms)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Dielectric Dissipation Factor</td>
<td>0.002 Max.</td>
<td>IS: 6262</td>
</tr>
<tr>
<td></td>
<td>(Tan delta) at 90 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Specific Resistance ( Resistively)</td>
<td></td>
<td>IS: 6103</td>
</tr>
<tr>
<td></td>
<td>a) @ 90 °C</td>
<td>35 x10¹² Ohm-cm (Min.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) @ 27 °C</td>
<td>1500 x10¹² Ohm-cm (Min.)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Oxidation Stability</td>
<td></td>
<td>IEC 61125 (method C)</td>
</tr>
<tr>
<td></td>
<td>a) Neutralization value after Oxidation for 164 Hrs. @ 100 °C</td>
<td>0.40 mg/ KOHp gm Max.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Total sludge after oxidation for 164 Hrs. @ 100 °C</td>
<td>0.10% by weight max.</td>
<td></td>
</tr>
<tr>
<td>Sr. No.</td>
<td>Characteristics of Transformer Oil</td>
<td>Requirement</td>
<td>Method of test</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
</tbody>
</table>
| 13      | Ageing Characteristics after 96 Hrs accelerated ageing (Open beaker method with copper catalyst)  
  a) Specific Resistance (Resistivity)  
  1) @ 27 °C  
  2) @ 90 °C  
  b) Dielectric Dissipation Factor (Tan delta) @ 90 °C  
  c) Total acidity  
  d) Total sludge value | 2.5 X 10^{12} Ohm-cm-Min.  
  0.2 X 10^{12} Ohm-cm min.  
  0.2 Max.  
  0.05 mg. KOH/gm Max.  
  0.05 % by weight Max. | ASTM/D 1934/IS: 12177 |
| 14      | Presence of Oxidation inhibition | Absent | IS: 335  
  Appendix: D |
| 15      | Water content PPM (Max)  
  New untreated oil  
  After treatment | 50 PPM Max.  
  05 PPM Max. | IS: 2362  
  IS: 1866 |
| 16      | Poly Chlorinated Biphenyls (PCB) Content | NIL | IEC 61619  
  Doble spec |
| 17      | Gassing tendency at 50 hZ, after 120 minutes | 5 mm³ per minute (Max.) | Doble spec |

### 2.8.0. TERMINAL ARRANGEMENT

**2.8.1.** Bushings: The bushings shall conform to the following requirements.

a) The electrical and mechanical characteristics of bushing shall be accordance with IS: 2099 and IS 3347 (Part III / Section - I).

b) Bushings for voltage of 420 KV shall be of the oil filled condenser type and shall preferably be of the draw lead type to facilitate removal. For voltage 36 kV and below, solid porcelain of oil communicating type bushings may be used.

c) Condenser type bushings shall be provided with

i) Oil level gauge

ii) Oil filling plug and drain valve if not hermetically sealed.
iii) Tap for capacitance test.

d) When bushings have an under-oil end of re-entrant form, the pull through lead shall be fitted with a gas, bubble deflector.

e) Where current transformers are specified, the bushings shall be removable without disturbing the current transformer.

2.8.2. **Terminal connectors:**

a) Bushing terminal shall be provided with terminal connectors of approved type and size for connection to external parts.

b) Requirements of terminal connectors will be intimated to the contractor.

c) i) All castings shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred.

   ii) No part of clamp / connector shall be less than 10mm thick.

   iii) All ferrous parts shall be hot dip galvanizes confirming to IS : 2633.

   iv) For bimetallic clamps, copper alloy liner of minimum 2mm thick shall be case integral with aluminum body.

   v) Flexible connector shall be made from tinned copper shapes.

   vi) Size of terminal / Conductor for which the clamp is suitable and rated current under site conditions shall be embossed / punched in each component of the clamp, except hardware.

   vii) All current carrying parts shall be designed and manufactured to have minimum contact resistance.

   viii) Clamps shall be designed corona controlled and shall conform to IS : 5561.

2.8.3  **The height of live part shall be so arranged that minimum clearance up to plinth shall be maintained as per safety clearances from latest CBIP guide.**

2.9.0. **TERMINAL MARKING:**

The terminal marking and their physical position shall be in accordance with IS: 2026.

2.10.0. **NEUTRAL EARTHING ARRANGEMENT:**

a) The neutral of the Shunt Reactor shall be brought out through adequately rated 145 kV oil filled condenser bushing.

b) The neutral shall be directly grounded through a neutral grounding reactor. The contractor shall provide connections between neutral of the shunt reactor, surge arrester and the neutral grounding reactor.

c) The contractor shall provide all accessories required for grounding of the neutral.
d) Neutral of bus reactors, where neutral grounding reactor is not provided, shall be grounded directly.

e) The neutral terminals of bus reactor and Neutral grounding reactors 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) 75x12 mm galvanized steel flats connected to Employer's grounding mat.

f) A twin tinned copper strip grounding conductor of 50 x 6 mm size shall be provided from the neutral terminal to transformer base for connection to the sub-station grounding grid. Necessary pin insulator, clamps, bolts etc. shall be supplied for this grounding purpose.

g) Neutral bushing to grounding conductor shall be made through twin copper flexible strip of size 50 x 10 mm.

2.11.0 COOLING EQUIPMENT:

Oil immersed with natural cooling (ONAN)
a) The radiator bank of the Shunt Reactor shall be either separately mounted, or tank mounted. For neutral grounding reactor, the radiator, if required, may be tank mounted.

b) Radiators shall be made from pressed steel.

c) Each radiator bank shall be provided with the following accessories.
i) Top and bottom shut off valve.
ii) Drain valve and sampling valve.
iii) Air release plug.
iv) Two grounding terminals of two (2) 75x12 mm galvanized steel flats.
v) Lifting lugs

d) Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches.

e) Expansion joint, if required, shall be provided on top and bottom cooler pipe connection.

2.12.0 Valves:

a) All valves up to and including 100mm shall be of gun metal or of cast steel, larger valves may be of gun metal or may have case iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock-wise when facing the hand wheel.

b) Means shall be provided for pad-locking the valves in the open and close positions, provisions is not required for locking individual radiator valves.

c) Each valve shall be provided with the indicator to show clearly the position of the valve.

d) All valve flanges shall have machined faces.
e) All valves in oil line shall be suitable for continuous operation with shunt reactor oil at 100 °C.

f) Gland packing / gasket material shall be of Teflon rope / nitrile rubber. In case of gate / globe valves, gland packing preferably of Teflon rope shall be used to prevent oil seepage through the gland.

g) The oil sampling point for main tank should have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 100 mm size to facilitate oil sampling.

h) A valve or other suitable means shall be provided to fix the on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location and size of the same shall be finalized during detailed engineering stage.

i) After testing inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resistive paint / vanish. Out surface of the valves shall be painted with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint confirming to IS:2932 and of a shade (preferably red or yellow) distinct and different from that of main tank surface. Outside surface except gasket seating surface of butterfly valves shall be painted with two coats of red oxide zinc chromate confirming to IS:2074 followed by two coats of fully glossy finishing paint.

j) All hardware used shall be cadmium plated / electro galvanized.

2.13.0. MARSHALLING BOX:

a) A sheet steel, vermin proof, weather proof marshalling box of a suitable construction shall be provided for the reactor ancillary apparatus. The interior and exterior painting shall be in accordance with clause 2.13.0. The degree of protection shall be IP 55 in accordance with IS:2147. It shall have double hinged door with pad lock and pad locking arrangement.

b) The marshalling box shall accommodate the following:

i) Temperature indicator for winding and oil. All shunt and neutral grounding reactors shall be provided with a 150 mm dial

ii) Terminal boards and gland plates for incoming and outgoing cables.

c) The temperature indicator shall be so mounted that the dials are not more than 1600mm from ground level doors of the compartment shall be provided with glazed windows of adequate size.

d) To prevent internal condensation, a space heater shall be provided. It shall be so designed that with the space heater 'ON'
continuously, the temperature inside the marshalling box does not exceed the safe operating limits at the service conditions.

e) All incoming cable shall enter from bottom and the gland plate shall not be less than 450mm from the base of the box. The gland plate and associated compartment shall be sealed in a suitable manner to prevent ingress of moisture from the cable trench or conduit.

f) All box wiring shall be in accordance with latest edition of IS:375.

2.14.0. PAINTING:

a) The surface to be painted shall be shot or sand blasted to remove all rust and scale or foreign adhering matter or grease.

b) All steel surfaces in contact with insulating oil shall be painted with heat resistant and oil insoluble insulating varnish.

c) All steel surfaces exposed to weather shall be given primary coat of Zinc chromate, second coat of oil and weather resistant varnish of a colour distinct from the primary, and final two coats of glossy oil and weather resisting, battle ship grey paint shade 631 of IS:5, in accordance with applicable standard as specified.

d) All paints shall be carefully selected to withstand heat and extremes of weather. The paint shall not scale or crinkle or be removed by abrasion due to normal handling.

2.15.0. CONTROL WIRING:

a) All controls, alarms, indicating and bushing CT terminals relaying devices provide with the reactor shall be wired up to the terminal blocks inside the marshalling box.

b) All devices and terminal blocks within the marshalling box shall be clearly indicated by symbols corresponding to those used in applicable schematic or wiring diagram.

c) At least 20% spare terminals shall be provided and each terminal shall be suitable for connecting two 7/0.737 mm copper conductors from each side.

d) All control wiring from reactor accessories to marshalling boxes is in the scope of the contractor and shall be done with 1100/600 volts grade standard copper conductor.

2.16.0. FITTINGS:
The fittings listed hereunder, are only indicative and any other fittings which generally are required for satisfactory operation of the reactor and neutral grounding reactor are deemed to be included.

Reactor fitting shall include, but not necessarily be limited to the following items.

a) Conservator for reactor main tank with filling hole and cap, drain valve, isolating valve, vent pipe and magnetic oil level gauge with low level alarm contacts. Conservator for NGR main tank with drain valve, isolating valve, vent pipe and prismatic oil level gauge shall be provided.

b) Explosion vent with diaphragm / pressure relief device.

c) Air release devices.

d) Inspection covers

e) Dehydrating breather complete with first fill of activated silicagel.

f) Rating & diagram plate for reactors, NGR, SA and current transformers.

g) Terminal marking plate conforming to IEC-289 / IS:5553 (Part-I).

h) Two earthing terminals each on Reactor tank, NGR tank, Radiator & marshalling box, SA structure etc.

i) Magnetic type oil level indicator with 250mm dia. Dial and alarm initiating contacts for low oil level. Taps or valves shall not be fitted on oil gauge.

j) Suitable neutral bus connection. In case of 1-Ø Reactors all accessories including 2" IPS Aluminum pipe for forming the neutral shall be supplied.

k) Double float Buchholz Relay with alarm and tripping contacts.

l) Oil sampling and drain valve.

m) Filter valves at top and bottom.

n) Shut off valves on the pipe connection between radiator bank and reactor bank.

o) Shut off valves on both sides of Buchholz relay at accessible height.

p) Sampling gas collectors, for Buchholz relay at accessible height.
q) Four jacking pads.

r) Lifting lugs or eyes for the cover

s) Suitable terminal connectors on bushings and surge arrester.

t) Under-Carriage with flanged bi-directional wheels.

u) Drain valves/plugs shall be provided in order that each section of pipe work can drained independently.

v) All the gaskets to be provided shall be of RC70C or RC80C grade. Necessary tests certificates from manufacturer shall be submitted along with acceptance test report. The gasket to be used shall not be older than One year.

w) Necessary provision for installation of ‘HYDRAN – M2’ or equivalent On Line monitoring system, shall be made for satisfactory performance throughout the life of transformer. Location and size of the same shall be finalized during detailed engineering.

2.17.0 A) Oil Temperature Indicator:

All shunt reactors and neutral grounding reactors shall be provided with thermometer pocket for 150mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent, potential free contacts, compatible for SCADA remote operation, for.

i) Oil temperature High alarm.

ii) Independent potential free contacts for alarm and tripping for oil temperature too high conditions.

The maximum reading pointer and resetting device for the thermometer shall be mounted in the marshalling box. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least 2ºC. Accuracy class of OTI shall be ±1.5% or better.

B) Winding Temperature Indicator:

A device for measuring the hot spot temperature of winding shall be provided. It shall be compatible for SCADA remote operation & comprise of the following:

i) Temperature sensing element.

ii) Image coil

iii) Auxiliary Current Transformer if required to match the image coil shall be furnished and mounted in the marshalling box.

iv) 150 mm dia local indicating instrument with maximum reading pointer mounted in marshalling box and with adjustable electricity independent ungrounded contacts,
besides that required for control of cooling equipment, one for high winding temperature alarm and one for trip.

v) Calibration device.

vi) Automatic ambient temperature compensation In addition to the above, the following remote indication equipment shall be provided.

a) Signal transmitter
Signal transmitter shall have additional facility to transmit signal for recording winding temperature at Employer's data acquisition system, for which a 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 relevant standard. 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 each of these functions shall be provided.

b) Remote winding temperature indicator. It shall be suitable for flush mounting on owner's panel. This shall not be repeater dial of local WTI and will operate by signal transmitter.

A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to WTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least 2ºC. Accuracy class of WTI shall be ±1.5% or better.

C) Fiber Optic sensor temperature indicator system: Temperature measurement of Oil and winding shall also be done using Fiber Optic Sensors, meeting following criteria:

1. System shall be fiber optic rugged, proven technology. The probes shall be directly installed in each phase of transformer to measure the winding hotspot and top oil temperature. There will be total four probes inside the transformer, out of which one probe should be installed at top of the transformer for the detection of top oil temperature.

2. The remaining three (3) Fiber Optic probes should be installed in each phase at the hottest spots of each of the phase windings. The locations of the probe shall be proposed by the Manufacturer and locations finalized by agreement of the purchaser.

3. Probes shall be able to be completely immersed in hot transformer oil; they shall withstand exposures to hot kerosene vapor during the transformer installation drying process.

4. Temperature range of the system should be -30ºC to +200 ºC & accuracy of ±1% with no recalibration required.

5. Probes shall be 200im all silica double PFA Teflon jacketed, Kevlar cabled fiber with perforated outer jacket to allow complete oil filling and white Teflon protective Helix wrap for improved visibility and mechanical strength.
6. System should include analog outputs for each measurement channel. Temperature resolution of the analog outputs shall be ±0.1 °C and the systems shall offer a user programmable temperature alarm outputs with 6 relays, alarm lights and controller system status indicators. All inputs and outputs of the system shall meet the requirements of surge test of IEEE C37.90.1-1989 in which a 3000V surge is applied to all the inputs and outputs without permanent damage to the instrument.

7. The system shall be capable of retaining temperature data of 90 or more days at rate of One reading per minute and should retain maximum temperature of each channel until reset.

8. The manufacturer should submit data showing that the probes are located in the hottest point of the winding.

9. The Fiber Optic cable should be brought out of the main tank through tank wall penetrator feed through plate. The feed through plate shall be welded on the tank. The external fiber optic extension cable shall then be run to main control cabinet, routed inside the conduits with large bend radiuses.

10. The controller shall be housed in cooler control cabinet. Temperature rise test measurements shall be made with FO thermometers. The equipment shall be operational during temperature tests and demonstrated during these tests. During probe verification, the hottest probes for each phase shall be identified, and temperature data for all probes recorded and reported in the test report.

11. Transformer manufacturer shall confirm for full guaranteed performance of transformer with provision of FO sensors system. FO system shall cover all required accessories to indicate temperatures at local, remote and shall be SCADA compatible. Suitable change over facility of alarm & control contacts shall be provided for conventional thermal image type temperature indicators and fiber optic temperature indicators.

12. The FO system shall have suitable length of FO cable, sensor and probes.

13. The output of FO system shall be suitable for PC interface with USB port. All required softwares shall be provided.

14. Any other accessories required for satisfactory operation of fiber optic sensor temperature measurement system shall be provided.

15. All the type tests reports as per relevant standard shall be submitted with the technical bid. Acceptance tests shall be performed as per relevant standard.

16. Services of FO system supplier during manufacturing, testing, commissioning and after sales even beyond guarantee period shall have to be arranged and provided by the bidder.

2.18.0 TESTS AND INSPECTIONS:

2.18.1 Routine tests on shunt reactors:
All the routine/acceptance tests listed in IEC-289/IS-5553 (Part-I) shall be carried out on all the Reactors. In addition the following routine tests shall also be carried out on each Shunt Reactor. All the instruments, meters, etc., used for testing shall be duly calibrated at NABL laboratory and necessary calibration certificate shall be made available during inspection.

i) Switching impulse on line terminals IS:2026 (Part-III)

ii) Induced over-voltage with partial discharge measurement as per IS: 2026 (Part III)
Acceptance Criteria for PD:
PD levels measured at the end of 60 minute test period shall not exceed 100 pC or show any rising tendency in the last 15 minutes of more than 5%. Gas evolution of DGA before and after PD test shall be interpreted in line with IEC/ CIGRE guidelines.

iii) Oil leakage test on Reactor tank.

All tanks and oil filled compartments shall be completely filled with air/oil of a viscosity not greater than that of insulating oil to IS:335 at the ambient temperature and subjected to a pressure equal to normal tank pressure plus 35KN/m² (5 lbs/sq.in) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hrs. for oil and for 1 hour for air during which no leakage shall occur.

iv) SFRA test at factory and at site.

v) Vibration and stress measurement test.

vi) Load Loss and current measurements:
The load losses and load current of every reactor shall be measured as specified in IEC 60076/ IEC 60289. Measurements shall also be made with maximum flux condition in magnetic circuit. In each case the measurement shall be made at 0.90pu, 1.00pu & 1.10pu.

The following details shall be recorded and submitted with the test certificates
(a) The voltage readings.
(b) The mode of response and scaling of voltmeters.
(c) The current reading.
(e) The power reading.
(f) The frequency reading.
(g) The instrument constants and correction.
(h) Correction made to power and current results due to non sinusoidal wave form of voltage and current.
(j) The magnetization curve of the reactor

vii) Core assembly dielectric and earthing continuity tests
The insulation of the magnetic circuit and between the magnetic circuit and the core clamping structure, including core bolts,
bands and / or buckles shall withstand the application of a test voltage of either 2 kV AC or 3 kV DC for 60 seconds.

viii) Reactance and loss measurement
   (a) The type tested unit shall be measured in cold and hot state
   (b) In other units, measurement shall be carried out in the cold state and corrected as per factors derived from type tests.

ix) 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 20 deg Cent. Temperature correction factor table shall be given by the bidder and shall form the part of test results. The Maximum Limit of value of tan delta shall be 1% for windings, 0.5% for bushings and 0.2 % for oil.

x) Tests on FOS (Fiber optic system)
xi) Tests on Air cell
xii) Tests on oil: Tests on transformer oil including DGA on selected sample as per IS:9434/IEC:567, before & after temp rise test and at final stage before dispatch.
xiii) Vacuum test on Reactor tank
xiv) Pressure test on Reactor tank
xv) Tests pressure relief device
xvi) Partial discharge measurement of reactor. The partial discharges in the reactor at the time of dispatch shall not be more than 500 pC.
xvii) Separate source voltage withstand test
xviii) Measurement of insulation resistance of winding
xix) High voltage withstand test on auxiliary equipment and wiring after assembly.
xx) Measurement of knee point voltage and tests on bushing CTs
xxi) Appearance construction and dimensional checks
xxii) Measurement of Zero sequence

2.18.2 Type tests on Shunt Reactor:
Following type tests reports shall be submitted with the offer. The type test reports shall not be older than FIVE years and shall be valid up to expiry of validity of offer.

Important note for type tests: The type test report shall be submitted for the offered class and rating of reactor. However, the type test report for higher class/rating can be accepted for scrutiny of technical bid but the same test/s shall have to be carried out on the offered class/rating reactor. Bidder shall invariably confirm to carry out the required type test/s, special tests, before commencement of supply, without affecting delivery schedule, free of cost, at NABL approved laboratory, or at suppliers works in presence of GETCO representative, in the event of order.

i) Measurement of winding resistance
ii) Reactance measurement
iii) Measurement of harmonic content of phase current
iv) Temperature rise test
v) Lightning impulse voltage withstand test
vi) Lightning impulse voltage withstand test on neutral
vii) Switching impulse test
viii) Measurement of acoustic noise level
ix) Vibration and stress measurement  
x) Knee point voltage measurement of reactor  
xi) Measurement of load loss and current  
 xii) Tests on Fiber Optic sensors  
xiii) Seismic test  
xiv) Degree of protection test on Marshalling box, as per IP:55 in accordance with IS:13947  
xv) Tests on Air cell  
xvi) Tests on bushings

Following type tests shall be conducted on each Shunt Reactor of each rating:

i) Test of temperature rise-clause 17.4 of IEC-60289. Gas chromatographic analysis test on oil shall be conducted before and after this test. 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 per IS:9434 (based on IEC:60567) and results interpreted as IS:10593 (based on IEC-60599/CIGRE guideline). The test shall be done for a minimum of 24 hrs with saturated temperature for at least 4 hrs.  
The temperature rise measurements shall be made with the Fiber Optic Thermometers & conventional OTI/WTI. The FOS shall also be operational during temperature tests and demonstrated during these tests. During probe verification, the hottest probes for each phase shall be identified, and temperature data for all probes recorded and reported in the test report. Data obtained from FOS and conventional OTI/WTI shall be compared however, both values should satisfy the commitment.

ii) Measurement of Zero-Sequence reactance clause 16.10 of IS: 2026 (Part-I) for 3-ph reactor only.

iii) Measurement of acoustic noise level clause 16.12 of IS: 2026 (Part-I)/IEC: 60076

v) Measurement of winding resistance
vi) Reactance measurement
vii) Measurement Harmonic content of phase current
viii) Switching impulse test
ix) **Measurement of knee point voltage of reactor**
x) **Measurement of load loss and current**
 xi) ACLD test

2.18.3 **Routine tests on neutral grounding reactor:**

In addition to the routine tests listed in the IEC-289 / IS:5553 the voltage-current characteristics test shall also be carried out on each neutral grounding reactor preferably at least up to short time rated current. Calculated value of hot spot temperature shall be furnished by the contractor. Further lightning impulse voltage test and ohmic value measurement shall be carried out.
2.18.4 **Type tests on neutral grounding reactor:**
The following type tests shall be conducted on one neutral grounding reactor.

i) **Impulse voltage withstand test (as per IEC-289).** If the bidder wishes to utilize the option of conducting impulse voltage withstand test as a routine test in lieu of inter turn voltage withstand / induced over voltage withstand test, there is no need to conduct this test as a type test.

ii) **Tank vacuum and tank pressure tests on one NGR tank.**

2.18.5 **Routine tests on Surge Arrester:** The surge arresters shall conform to shall be subjected to routine tests as per IEC: 60099-1/IEC:60099-4. Also following additional acceptance tests shall be performed

1. Constructional check (visual check)

2.18.6 **Type tests on Surge Arrester:** The surge arresters shall conform to type tests as per IEC: 60099-1 / IEC: 60099-4.

2.18.7 **Routine tests on bushings:**
The following tests shall be conducted on bushings as per IEC: 60137

i) **Test for leakage on internal filling**

ii) **Measurement of creepage distance, dielectric dissipation factor and capacitance.**

iii) **Dry power frequency test on terminal and tapping**

iv) **Partial discharge test followed by dielectric dissipation factor and capacitance measurement.**

2.18.8 **Type tests on bushings:**
All the type tests as per IS: 2099 / IEC: 60137 including snap back test.

2.18.9 **Routine tests on fittings:**

i) **PRD:** Each pressure relief device shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in reactor tank pressure test. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.

ii) **Buchholz relay & OSR:** The oil shall be drained through drain plug and to check for instant operation of alarm and tripping contacts.

2.18.10 **Type tests on fittings:**

i) **Buchholz relay:** As per IS:3637

ii) **Terminal box for buchholz relay, PRD, MOG, OSR, control cabinet, MK box, etc.:** Degree of Protection IP:55 (Material, thickness & type of gasket shall be indicated)

iii) **PRD:** 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 reactor tank pressure test. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.

v) OTI & WTI: Switch setting & operation, switch differential, switch rating.

vi) Terminal connector: As per IS: 5561
   1) Tensile test
   2) Resistance test
   3) Temperature rise test
   4) Short Time current withstand test (40 kA for 3 sec)
   5) Dimensional checks
   6) Galvanizing test
   7) Chemical analysis test
   8) Corona and RIV measurement test (for 400 kV and above)

2.18.11 The owner will have the right of having at its own cost any other test(s) of reasonable nature, carried out at contractors premises or at site or at any other place in addition to the aforesaid type and routine tests to ensure that the equipment complies with the specification.

2.18.12 All the tests would be carried out at full voltage and frequency.

2.18.13 If the tests cannot be done at factory with full voltage and frequency due to any reason, then these would be carried out by alternative methods as per the provision in IEC-289/ IS:5553. In such a case no extra cost will be paid by the purchaser due to alternate / modified test methods.

2.18.14 The owner reserves the right to witness any or all of the tests.

2.18.15 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.
The contractor shall bear all additional costs related to test which are not possible to carry out at his own works.
A typical test plan for reactor is indicated below. The contractor shall submit an inspection and test plan (ITP) of each item separately for approval.

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<td>21</td>
<td>Measurement of Zero Sequence reactance (3 phase)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Measurement of insulation resistance of windings</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Measurement of insulation power factor and capacitance between winding and earth</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Induced over voltage test with P D measurement</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>ACLD test</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Tests on Oil (DGA at initial, after temp rise &amp; at final stage before dispatch)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Appearance, construction and dimension check</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Core assembly dielectric and earthing continuity test</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Sweep Frequency Response analysis at FAT &amp; SAT</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>High voltage withstand test on Auxiliary equipment and wiring after assembly</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Oil leakage on assembled Reactor</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Tests on Pressure Relief Devices</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Meas of Knee point voltage &amp; tests of bushing CT</td>
<td>√</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

H/C Measured in Hot and Cold state of temperature rise test
C Measured in cold state

**2.19.0 TANK TESTS:**

a) Vacuum Test
One Reactor tank and neutral grounding reactor tank shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/M$^2$ absolute (25 torr) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the values specified below:

<table>
<thead>
<tr>
<th>Horizontal length of Flats 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>

b) Pressure Test:

One reactor tank and neutral grounding reactor tank of each size together with its radiator, conservator vessel and other fittings shall be subjected to a pressure corresponding to twice the normal head of oil or normal pressure plus 0.35 kg/cm$^2$ whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of flat plate after the excess pressure has been released shall not exceed the figures specified above.

c) Relief Device Test:

The pressure relief device of each size shall be subjected to increasing oil pressure and shall operate before reaching the test pressure specified in test at (b). The operating pressure shall be recorded.

2.19.1 a) Two (2) sets of certified test reports and oscilograms shall be submitted for approval prior to dispatch of the equipment. The equipment shall be dispatched only when all the required type and routine tests have been carried out and their test reports have been approved by the owner.

b) Two (2) copies of the test reports for the tests carried out on the ancillary apparatus shall be furnish to the owner for their approval prior to dispatch.

2.20.0 **INSPECTION:**

a) The contractor shall carryout a detailed inspection and testing programme for manufacturing activities of the various components. An Inductive programme of inspection as envisaged by the engineer is given below. This is not however, intended at to form a comprehensive programme as it is contractor's responsibility to draw up and carryout such a program duly approved by the Engineer.
b) Cost of inspection / test is to be borne by the Contractor.

c) Additional tests, if required are to be deemed as included in the scope of work.

d) Stages of inspection and owner's participation would be defined and tied up at the time of award of contract.

2.20.1 TANK AND CONSERVATOR:

a) Certification of chemical analysis and material tests of plates.
b) Welder's and welds procedure qualification.
c) Testing of electrodes for quality of base materials.
d) Inspection of major weld preparation.

e) Crack detection of major strength weld seems by dye penetration tests.
f) Measurement of film thickness of
   - Oil insoluble varnish
   - Zinc chromate paint.
   - Light grey paint.
g) Check correct dimensions between wheels, demonstrate turning of wheels through 90°C and further dimensional check.
h) Check for physical properties of materials for lifting lugs, jacking pads etc. All load bearing welds including lifting lugs welds shall be subjected to NDT.
i) Leakage test of the conservator.
j) Certification of all test results.

2.20.2 CORE:

a) Sample testing of core material for checking specified loss, bend properties, magnetization characteristics and thickness.
b) Check on the quality of varnish if used on the stampings.
c) i) Measurement of thickness of varnish on stampings.
   ii) Solvent resistance test to check the varnish does not react in hot oil.
   iii) Check over all quality of varnish on stamping to ensure uniform shining colour, no bare spots; No over burnt varnish layer and no bubbles on varnish surface.

d) Check on the amount of burrs.
e) Bow check on stampings.
f) Check for the overlapping stampings, corners of the sheets are to be apart.
g) Visual and dimensional check during assembly stage.
h) Check for inter-laminar insulating between core sections before and after pressing.
i) Check on completed core for measurement of iron-loss and check for any hot spot by exciting the core so as to induce the designed value of flux density in the core.

j) Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.

k) High voltage test (2 kV for one minute) between core and clamps.

l) Certification of all test results.

2.20.3 **Insulating Materials**

a) Sample check for physical properties of material.

b) Check for dielectric strength.

c) Visual and dimensional checks.

d) Check for the reaction of hot oil on insulating materials.

e) Certificate of all test results.

2.20.4 **Winding:**

a) Sample check on winding conductor for mechanical properties and electrical conductivity.

b) Visual check on conductor for scratches, dent marks etc.

c) Sample check on insulating paper for PH value, electric strength.

d) Check for the reaction of hot oil in insulating paper.

e) Check for the bending of the insulating paper on conductor.

f) Check and ensure that physical condition of all material taken for winding is satisfactory and free of dust.

g) Check for absence of short circuit between parallel strands.

h) Check for brazed joints wherever applicable.

i) Measurement of voltage to be carried out when core/yoke is completely restacked and all connections ready.

j) Certificate of all test results.

2.20.5 **Check before drying process:**

a) Check conditions of insulation on the conductor and between the windings.

b) Check insulation instances between high voltage connection cables and earth and other live parts.

c) Check insulation distance between low voltage connections and earth and other parts.

d) Insulation test of core earthing.

e) Check for proper cleanliness and absence of dust etc.

f) Certification of all test results.

2.20.6 **Check during Drying Process:**


b) Check for completeness of drying.

c) Certification of all test results.
2.20.7  Assembled Reactor:

a) Check completed reactor against approved outline drawing: Provision for all fittings, finish level etc.  
b) Jacking test on all the assembled reactors.

The contractor shall also prepare a comprehensive inspection and testing programme for all brought out/sub contracted items and shall submit the same to the Engineer for approval. Such programme shall include the following:

a) Buchholz Relay  
b) Sudden pressure rise relay.  
c) Axles and wheels/trolley for transportation.  
d) Winding temperature indicators for local and remote mounting.  
e) Oil temperature indicators.  
f) Bushings  
g) Bushing Current Transformers  
h) Pressure Relief Device  
i) Marshalling box  
j) Radiators  
k) FO system

2.21.0  PRE SHIPMENT CHECKS AT MANUFACTURER'S WORKS:

a) Check for interchangeability of components of similar Reactors for mounting dimensions.  
b) Check for proper packing and preservation of accessories like radiators, bushings, explosion vent, dehydrating breather, rollers, buchholz relay, control cubicle, connecting pipes conservator etc.  
c) Check for proper provision of bracings to arrest the movement of core and binding assembly inside the tank.  
d) Gas tightness test to conform tightness'.  
e) Derivation of leakage rate and ensure adequate reserve gas capacity.

2.22.0  INSPECTION AND TESTING AT SITE:

The contractor shall carryout a detailed inspection and testing program for field activities, namely, covering area right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the engineer is given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a program duly approved by the Engineer.

2.23.0  RECEIPT AND STORAGE CHECKS:

a) Check and record condition of each package, visible part of the Reactors etc. for any damage.
b) Check and record of the gas pressure in the reactor tank as well as in the cylinder.
c) Visual check for wedging of core and coils before filling up with oil and also check condition of core and winding in general.

2.24.0 INSTALLATION CHECKS:

Test on oil samples taken from main tank top and bottom and cooling system as per IS:335.
Sample should be taken only after the oil has been allowed settle for 24 hours.

a) Check the whole assembly for tightness, general appearance etc.
b) Oil leakage tests
c) The contractor shall warrant that oil supplied is in accordance with the specification given in this specification.

2.25.0 COMMISSIONING CHECKS:

a) Check the colour of silicagel of breather.
b) Check the oil level in the breather housing, conservator tank, cooling system, condenser, bushing etc.
c) Check the bushings for conformity of connection to the line etc.
d) Check for correct operation of all protections and alarms.
   i) Buchholz Relay
   ii) Excessive winding temperature
   iii) Low oil flow
   iv) Excessive oil temperature
   v) Low oil level indication.

e) Check for adequate protection on electric circuit supplying the accessories.
f) Insulation Resistance measurement.
g) Check for cleanliness of the Reactor and the surrounding.

2.26.0 ERECTION AND COMMISSIONING

2.26.1 The bidder shall quote for the services of an Erection Engineer who shall assume full responsibility for the erection, testing and commissioning of the equipment. Skilled and unskilled labour and normal erection tools would be provided by the purchaser. All special erection tools as well as instruments required for the erection, testing and commissioning of the Shunt Reactors shall be provided by the bidder.

2.26.2 Bidder shall indicate days and per man-day rates for the services of the Erection Engineer. Bidder shall also indicate the estimated duration required for the Erection, testing and commissioning of the equipment offered.

2.26.3 Purchaser shall provide local workman as well as all ordinary tools required for erection, at his own expense, Apart from the above, the
purchaser shall not be responsible for any other expenses incurred by
the bidder and expenses such as Erector's salary, insurance against
personal injuries to the Erectors etc. shall be to the Tender's account.

2.27.1 PACKING AND TRANSPORT INSTRUCTIONS:

Bidder shall ensure that all equipment covered by this specification shall
be prepared for rail/road transport and be packed in such a manner as
to protect it from damage in transit. The bidder shall be responsible for
and make good at his own expense any or all damage due to improper
preparation and packing. The reactor shall be fitted with sufficient
number of impact recorders during transportation to measure the
movement due to impact in all three directions. The impact recorder
shall be provided with suitable communication port (USB port) to down
load data at any time. The impact recorder shall be Return after
submission of all the data in hard and soft copy.

2.27.2 Loose materials, bolts, nuts, etc. shall be packed in gunny bags and
sealed in polythene bags with proper tagging.

2.27.3 Components containing glass shall be carefully covered with shock
absorbing protective material such as 'Thermo Cole'.

2.27.4 All opening in the equipment shall be tightly covered plugged or capped
to prevent dust and foreign material from entering in.

2.27.5 Wherever necessary, proper arrangements for attaching slings for lifting
shall be provided.

2.27.6 Any material found short inside the intact packing cases shall be
supplied by the Vendor/contractor at no extra cost to the Purchaser.

2.27.7 No material shall be dispatched without prior consent of the purchaser or
his authorised representative.

2.28.0 TECHNICAL AND GUARANTEED PARTICULARS

The bidder shall furnish all guaranteed technical particulars as called for
in Schedule - B, Section-II of this specification. Bids lacking information
in this respect may not be considered.

2.29.0 BASIS OF AWARD

2.29.1 The bidder shall quote for complete equipment as per this specification
and as specified in the schedule of requirements. The tender shall be
evaluated accordingly.

2.29.2 For the purpose of comparison of bids, the best parameter of loss
quoted for Shunt Reactor by any bidder, shall be taken as basis and the
quoted prices of other bidders shall be brought at par by loading for the
losses at the rate of Rs.50,000 / K.W. loss differential. Any change in
the figures assigned to reactor losses will not be permitted after opening of the bids and bid evaluation will be carried out on the basis of information made available at the time of bid opening.

2.29.3 The total losses in KW at rated MVAR, rated voltage and frequency shall be guaranteed under penalty. For the purpose of penalty computations, the test figures of the total losses will be compared with the corresponding guaranteed figures plus tolerances for them specified in IEC-60289. The penalty shall be calculated at the rate of Rs. 50,000/- per KW for excess of the total losses. For fraction of a KW, the penalty shall be applied prorated. If the test figures of losses are less than the guaranteed values, no bonus will be allowed.

2.30.0 SURGE ARRESTER:

2.30.1 GENERAL:
The surge arrester shall conform in general to IS: 3070(part-I) and IEC:60099-1 or IEC:60099-4 except to the extent explicitly modified in the specification.
The bidder shall offer surge arresters of gapless type without any series or shunt gap.
Arresters shall be hermetically sealed units, of self supporting construction, suitable for mounting on structures.

2.30.2 Duty Requirements:
i) The surge arresters shall be of heavy duty station class type. It shall be physically located between the neutral of 420 kV shunt reactor (brought out at 145 kV class bushing) and neutral grounding reactor and shall be electrically in parallel with the latter.
ii) The surge arrester shall be capable of discharging over voltage occurring during switching of unloaded transformers and reactors.
iii) Surge arresters shall be capable of spark over on severe switching surges and multiple strokes.
iv) The surge arrester shall be able to withstand wind load calculated at 150 kg/sq.m.
v) The gapless arrester shall meet following additional requirements.
   a) It shall be fully stabilized thermally to give a life expectancy of 100 years under site conditions and shall take over care of the effect of direct solar radiation.
   b) The reference current of the arrester shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

2.30.3 Constructional Features:
The features and constructional details of surge arresters shall be in accordance with requirement stipulated hereunder:

   a) Gapless Type Surge Arrester
      i) The non linear blocks shall be of sintered metal oxide Material. These shall be provided in such a way as to obtain robust construction, with excellent electrical and mechanical properties even after repeated operations.
ii) The surge arrester shall be fitted with pressure relief devices and arc diverting parts suitable for preventing shattering of porcelain housing and providing path for flow of rated fault currents in the event of arrester failure.

iii) The arresters shall be incorporated anti-contamination feature to prevent arrester failure consequent to uneven voltage gradient across the stack in the event of contamination of the arrester porcelain.

iv) Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

v) Outer insulator shall be porcelain used shall be homogenous, free from laminations, cavities and other flaws or imperfection that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impressions to moisture. Glazing of porcelain shall be of uniform brown colour, free from blisters, burrs and other similar defects. Porcelain housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to the maximum design value for arrester.

vi) The end fitting shall be made of non-magnetic and corrosion proof material.

vii) The name plate shall conform to the requirement of IEC incorporating the year of manufacture.

viii) The arrester shall be supplied with suitable support structure either of tubular GI pipe or lattice steel galvanized.

ix) The heat treatment cycle details along with necessary quality checks used for individual blocks along with insulation layer formed across each block to be furnished. Metalized coating thickness for reduced resistance between adjacent discs to be furnished along with procedure for checking the same. Details of thermal stability test for uniform current distribution of current on individual disc to be furnished.

b) Fittings and Accessories:

i) Each arrester shall be complete with insulating base, support structure and terminal connector. The height of the support structure shall be such that required ground clearance as per relevant standard is maintained. The structure would be made of galvanized steel generally conforming to IS:802. The surge arrester can also be mounted on the neutral grounding reactor in lieu of separate support structure.

ii) Self contained discharge counter, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation, shall be provide for each unit. The counter shall be visible through an inspection window from ground level. The counter terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends.

iii) Suitable milli ammeter on each arrester with appropriate connections shall be supplied to measure the resistor grading leakage current. The push buttons shall be mounted such that it can be operated from ground level.

iv) Discharge counter and milli ammeter shall be suitable for mounting on support structure of the arrester.

v) Grading/Corona rings shall be provided on each complete arrester unit as required for proper stress distribution.

c) Tests:
i) The surge arresters shall conform to type tests and shall be subjected to routine tests as per IEC: 60099-1 / IEC: 60099-4.

ii) Surge arrester shall be subjected to additional acceptance tests as follow:
   1. Constructional check (visual check)

2.31 QUALITY ASSURANCE PLAN:

The bidder shall invariably furnish following information's along with his offer, failing which his offer shall be liable for rejection. Information shall be separately given for individual type of equipments offered.

1. QAP for incoming material, in process and final checks and testing.
2. Statement giving list of important raw materials, names of sub suppliers for the raw materials, list of standard according to which the raw materials are tested. List of tests normally carried out on raw materials in presence of bidder's representatives, copies of test certificates.
3. Information and copies of test certificates as in (i) above in respect of bought out accessories.
4. List of manufacturing facilities available.
5. Level of automation achieved and list of areas where manual processing exists.
6. List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.
7. Special features provided in the equipment to make it maintenance free.
8. List of testing equipments available with the supplier for final testing of transformer specified and test plant limitation, if any, for the special acceptance and routine tests specified in the relevant standards. These limitations shall be very clearly brought out in 'The schedule of divinations' for specified test requirements.

Field Quality Plan shall be submitted with the technical bid.
Section-II

SCHEDULE - B

GUARANTEED TECHNICAL PARTICULARS
(This shall be enclosed with Technical bids)

SHUNT REACTOR:

1. Maker's Name

2. Governing Standard

3. Type of reactor

4. Type of cooling

5. Connection

6. a) Reactive power for continuous operation (MVAR)
   I) At rated voltage
   II) At highest voltage (i.e. 5% higher than rated) (MVAR)
   b) Rated voltage
   c) Temperature rise in oil above ambient temp. °C
   d) Temperature rise of winding by resistance above ambient temperature °C
   e) Rated frequency (Hz)

7. Number of Phases

8. a) Guaranteed losses at rated voltage and frequency at rated output and at 75°C average winding temperature (KW)
   b) Tolerance on above losses (%) 

9. Guaranteed max. losses at rated voltage and frequency at rated output at its percentage

10. Impedance:
    a) Positive sequence (Ohms)
    b) Zero sequence (Ohms)
11. Ratio of reactor (i.e. Q-factor)

12. Maximum remissible duration of service at 110% of rated voltage, starting from cold without exceeding permissible temperature rise (hrs.)


14. Test voltage (for winding)
   a) Lightning impulse (1.2/50 micro-seconds) withstand voltage (KV peak)
   b) Power frequency withstand voltage (KV rms.)
   c) Switching surge withstand voltage (KV peak)

15. Clearances:
   a) HV phase to Phase (mm)
   b) Phase to Ground (mm)
   c) Neutral to Ground (mm)

16. Approximate weights (kgs.)
   a. Core (kgs.)
   b. Winding (kgs.)
   c. Tank and fittings (kgs.)
   d. Oil (kgs.)
   e. Total weight (kgs.)
   f. Untanking weight (kgs.)
      (to provide access to core and coils)

17. Quantity of oil (including 10% extra) itars.

18. Conservator
   a) Total volume
   b) Volume between highest and lowest visible oil levels.

19. (a) Size of largest package (mm x mm x mm)
   (b) Weight of largest package (kgs.)
   (c) Gross weight to be handled (kgs.)
   (d) Gross volume to be handled (M3)
20. Bushing as per IS: 2099
   a) Type
   b) Maker's name and country of Manufacturer
   c) Momentary power Frequency withstand voltage
   d) One minute power frequency withstanding voltage
      i) Dry (KV)
      ii) Wet (KV)
   e) Power Frequency puncture voltage (KV)
   d) Full wave impulse withstand and voltage (KV)
   f) Impulse puncture voltage (KV)
   h) Total creepage distance in air
   i) Weight and dimensions of assembled
      Bushings. (KV)

21. Core
   a) Type of core
   b) Justification for type of core adopted
   c) Technical details of the core
      i) Material
      ii) Thickness in mm
      iii) Grade (Prime only)
      iv) Insulation of core lamination
      v) Press board material and thickness

22. Zero Sequence Reactance/ positive sequence reactance i.e. XO/XI

23. Range of voltage up to which impedance will be constant and magnetization
    curve up to 2.5 pu. Voltage.

24. Vibration level

25. Amount of unbalanced current in each phase when connected to symmetrical
    voltages.

26. Lifting jacks (mechanical screw jacks)
   a) Governing standards
   b) Number of Jacks included in one set.
   c) Type and make.
   d) Capacity
e) Pitch  
f) Lift  
h) Mean diameter of thread  

27. Capacitance value (Phase to Ground)  

28. Type of oil preservation system  

29. Harmonic content in Phase current  

30. Quality of oil (please enclose separate sheet for characteristics of oil)  

31. Cooling calculation shall be submitted
## SCHEDULE - B

GUARANTEED TECHNICAL PARTICULARS
(This shall be enclosed with Technical bids)

### NEUTRAL GROUNDING REACTOR:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>i)</td>
<td>Rated voltage from insulation strength considerations</td>
</tr>
<tr>
<td>ii)</td>
<td>Rated frequency</td>
</tr>
<tr>
<td>iii)</td>
<td>No of phases</td>
</tr>
<tr>
<td>iv)</td>
<td>Type</td>
</tr>
<tr>
<td>v)</td>
<td>Insulation</td>
</tr>
<tr>
<td>vi)</td>
<td>Max. continuous current</td>
</tr>
<tr>
<td>vii)</td>
<td>Rated short time current (10 sec)</td>
</tr>
<tr>
<td>viii)</td>
<td>Rated impedance at rated short time current</td>
</tr>
</tbody>
</table>

#### Bushings

<table>
<thead>
<tr>
<th></th>
<th>Line side</th>
<th>Ground side</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Rated voltage</td>
<td></td>
</tr>
<tr>
<td>ii)</td>
<td>Creepage distance (total) in mm</td>
<td></td>
</tr>
<tr>
<td>iii)</td>
<td>Mounting</td>
<td></td>
</tr>
<tr>
<td>iv)</td>
<td>Lightning Impulse (1.2/50 micro sec) withstand voltage (kVp)</td>
<td></td>
</tr>
<tr>
<td>v)</td>
<td>Power Frequency withstand voltage (kVrms)</td>
<td></td>
</tr>
</tbody>
</table>

#### Connection

<table>
<thead>
<tr>
<th>Insulation level for winding</th>
<th>Line side</th>
<th>Ground side</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Lightning Impulse (1.2/50 micro sec) withstand voltage (kVp)</td>
<td></td>
</tr>
<tr>
<td>ii)</td>
<td>Power Frequency withstand voltage (kVrms)</td>
<td></td>
</tr>
</tbody>
</table>
| iii) | Max. admissible temperature rise over ambient temperature of 50ºC at rated voltage  
  a) of winding measured by resistance  
  b) of top oil measured by thermometer |
| iv) | Cooling system |
| v) | Cooling medium |
| vi) | Whether neutral is to be brought out |
| vii) | Method of grounding |
SCHEDULE - B

GUARANTEED TECHNICAL PARTICULARS
(This shall be enclosed with Technical bids)

SURGE ARRESTERS:

1. Name and address of Manufacturer:

2. Manufacturer's type designation :

3. Applicable standards :

4. Arrester class and type :

5. Rated arrester voltage (kV) :

6. Rated system voltage (kV) :

7. Maximum continuous operating voltage :
   (COV) at 50 deg.C ambient temperature (kV)

8. Nominal discharge current(8/20 micro :
   sec.wave) (kA)

9. Minimum discharge capability ( kJ / kV) :

10. a) Maximum residual voltage at nominal :
    discharge current (kVpeak)

   b) Minimum residual voltage at nominal :
    discharge current (kVpeak)

11. a) Maximum residual voltage at 50 % nominal :
    discharge current (kVpeak)

   b) Maximum residual voltage at 200% nominal :
    discharge current (kVpeak)

12. Steep fronted wave residual voltage :
    at 1 KA (kVpeak)

13. Maximum switching surge impulse residual :
    voltage at 1 KA (kVpeak)

14. Long duration discharge class :

15. Impulse current withstand

   a) High current short duration (4/10
micro-sec wave) in kVpeak

b) Low current long duration :
   (2000 microsec.)

16. Current for pressure relief test (kA) :

17. Pressure relief class (as per IEC 99) :

18. One minute power frequency (dry) withstand :
   voltage of arrester housing (kVrms)

19. Lightning Impulse withstand test voltage of :
   arrester housing with 1.2/50 microsec wave (kVp)

20. Switching Surge Impulse withstand test voltage :
    of arrester housing with 250/2500 microsec wave (kVp)

21. Total creepage distance of whole arrester Housing (mm):

22. Cantilever strength of complete arrester (N) :

23. Total height of the arrestor (mm) :

24. Total weight of the arrestor (Kg) :

25. Maximum radio interference voltage at 1.1 Ur/ root 3 voltage at 1 MHz (microvolts)

26. Partial discharge at 1.05 continuous operating :
    voltage (pC)

27. Minimum prospective symmetrical fault current :
    (kArms)

28. Compliance to technical specification w.r.t :
    i) Surge monitor i) YES / NO
    ii) Support Insulator ii) YES / NO
    iii) Terminal connectors iii) YES / NO

29. ZnO block details :
    a) Make and size of ZnO block :
    b) Whether equipment type tested : YES / NO
       with offered type of ZnO block

30. Whether similar equipment are type tested : YES / NO
as per IEC/IS or equivalent standard and are in successful operation for at least two years.

31. Overall General Arrangement drawing of:
Surge arrester is to enclosed.
ANNEXURE C

**List of documents attached with technical bid:**

Bidder shall invariably attach the following documents and clearly marked and duly flagged in technical bid. In absence of these documents offer will be evaluated as a non submission.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars of document</th>
<th>Whether attached with tech bid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Drawings in AutoCAD format</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Drawings hard copies as indicated in specification</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Manual in PDF format</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>QAP for manufacturing process in SOFT format</td>
<td></td>
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<tr>
<td>5</td>
<td>QAP for manufacturing process in Hard format</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>FQP in SOFT format</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>FQP in Hard copy</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Type test Reports in hard copies</td>
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</tr>
<tr>
<td></td>
<td>a for reactor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b for NGR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c for clamps &amp; connectors</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Confirmation regarding type tests as per clause no. Cl. 1.30.3.1(b) page no. 32 – “IMPORTANT NOTE”</td>
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<tr>
<td>10</td>
<td>Cooling calculation</td>
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<tr>
<td>11</td>
<td>Guaranteed Technical Particulars, completely filled in</td>
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<td></td>
<td>a for reactor</td>
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<tr>
<td></td>
<td>b for NGR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c for SA</td>
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<tr>
<td>14</td>
<td>Any other essential documents</td>
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</tr>
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</table>
ANNEXURE - III

GUJARAT ENERGY TRANSMISSION CORPORATION LTD.

TECHNICAL SPECIFICATIONS FOR THE WORK OF DESIGN, SUPPLY, ERECTION AND COMMISSIONING INCLUDING CIVIL WORK OF NITROGEN INJECTION SYSTEM FOR PROTECTION AGAINST THE FIRE & EXPLOSION FOR TRANSFORMER.

TECHNICAL SPECIFICATION NO.
TECHNICAL SPECIFICATIONS

Name of work: Turnkey contract for the work of design, supply, erection and commissioning of Nitrogen Injection system for protection against the transformer explosion for 400 KV Transformers and Shunt Reactors as indicated in Annexure-I.

Each oil filled transformer / reactor shall be provided with a dedicated Nitrogen Injection system for prevention against the transformer explosion which shall use nitrogen as quenching medium. The system shall prevent transformer / Reactor oil tank explosion and possible fire in case of internal / external cause. In the event of fire by external causes such as bushing fire.OLTC fires, fire from surrounding equipment etc., it shall act as a fast and effective fire fighter. It shall accomplish its role as fire preventer and extinguisher without employing water or carbon dioxide. Fire shall be extinguished within reasonable with time (not more than 3 minutes so as not to harm the transformer) of system activation and within 30 seconds (maximum) of commencement of nitrogen injection. The system shall have been in successful operation / commissioned in Indian / Abroad installations for at least last five years for protection of transformers of 220 KV and higher voltage class. The list of past supplies in India / Abroad along with performance certificate from users of the system shall be submitted for approval of purchaser.

Activation of the system

Mal-functioning of the Nitrogen injection system could lead to interruption in power supply. The supplier shall ensure that the probabilities of chances of malfunctioning of the Nitrogen injection system are practically zero. To achieve this objective, the supplier shall plan out scheme of activating signals which should not be too complicated to make the system inoperative in case of actual need. The system shall be provided with automatic controls to prevent the explosion of transformers. Besides automatic control, remote electrical push button control at Control box and local manual control in the cubicle shall also be provided. The following electrical-signals shall be used for activating the system under prevention mode/fire extinguishing mode.

Auto Mode

For prevention:

- Differential relay operation.
- Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay)
- Tripping of all circuit breakers (on HV & LV/IV side) associated transformer / reactor is the pre-requisite for activation of system.
For extinguishing

- Fire Detector
- Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay).

Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer / reactor is the pre-requisite for activation of system.

Manual Mode (Local / Remote)

Tripping of all circuit breakers (on HV & LV / IV side) associated with transformer / reactor is the pre-requisite for activation of system.

Manual Mode (Mechanical)

- Tripping of all circuit breakers (on HV & LV / IV side) associated with transformer / reactor is the pre-requisite for activation of system.

The system shall be designed to be operated manually in case of failure of power supply to the system.

General description

Nitrogen Injection system should be a dedicated system for each oil filled transformer / reactor. It should have a Fire Extinguishing Cubicle (FEC) placed on a plinth at a distance of 5-10 m away from transformer / reactor or placed next to the firewall (if fire fighting wall exists). The FEC shall be connected to the top of transformer / reactor oil tank for depressurization of tank and to the oil pit (capacity is approximately equal to 10% of total volume of oil in transformer / reactor tank / or existing oil pit) from its bottom through oil pipes. The FEC should house a pressurized nitrogen cylinder(s) which is connected to the oil tank of transformer /reactor oil tank at bottom. The Transformer Conservator Isolation Valve (TCIV) is fitted between the conservator tank and Buchholz relay. Cable connections are to be provided from signal box to the control box in the control room, from control box to FEC and from TCIV to signal box. Detectors placed on the top of transformer / reactor tank are to be connected in parallel to the signal box by Fire survival cables. Control box is also to be connected to relay panel in control room for receiving system activation signals.

Operation

On receipt of all activating signals, the system shall drain - pre-determined volume of hot oil from the top of tank (i.e. top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen
gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

**System components**

Nitrogen Injection system shall broadly consist of the following components. However, all other components which are necessary for fast reliable and effective working of the system shall deemed to be included in the scope of supply.

**CUBICLE (FEC)**

The Cubicle Frame shall be made of CRCA sheet of 3 mm (minimum) thick complete with the base frame, painted inside and outside with post office red colour (shade 538 of IS -5). It shall have hugged / hinged split doors fitted with high quality tamper proof lock. The doors, removable covers and panels shall be gasketted all round with neoprene gaskets. The degree of protection shall be IP55. The following items shall be provided in the Cubicle.

- Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer.
- Oil drain pipe with mechanical quick drain valve.
- Electro mechanical control equipment for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas.
- Pressure monitoring switch for back-up protection for nitrogen release.
- Limit switches for monitoring of the system.
- Butterfly valve with flanges on the top of panel for connecting oil drain pipe and nitrogen injection pipes for transformer / reactors.
- Panel lighting (CFL Type)
- Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.
- Space heater.

**Control box**

Control box is to be placed in the control room for monitoring system operation, automatic control and remote operation. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided.

- System Oil.
• TCIV open.
• Oil drain valve closed.
• Gas inlet valve closed
• TCIV closed
• Detector trip
• Buchholz relay trip
• Oil drain valve open
• Extinction in progress
• Cylinder pressure low
• Differential relay trip
• PRV / RPRR trip
• Transformer / reactor trip
• System out of service
• Fault in cable connecting fault detector
• Fault in cable connecting differential relay
• Fault in cable connecting Buchholz relay
• Fault in cable connecting PRV / RPRR
• Fault in cable connecting transformer reactor trip
• Fault in cable connecting TCIV
• Auto / Manual / Off
• Extinction release on / off
• Lamp test
• Visual / Audio alarm for AC supply fail
• Visual / Audio alarm for DC supply fail

As far as possible the control box should be such devised that all the transformers and reactors or group thereof should be controlled from single spot.

**Transformer Conservator Isolation Valve.**

Transformer conservator isolation valve (TCIV) to be fitted in the conservator pipe line, between conservator and buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator.

The TCIV should be of the best quality as malfunctioning of TCIV could lead to serious consequence. The closing of TCIV means stoppage of breathing of transformer / reactor.

Locking plates shall be provided for pad locking.
Detectors

The system shall be complete with adequate number of detectors (quartz bulb) fitted on the top cover of the transformer / reactor oil tank.

Signal box

It shall be mounted away from transformer / reactor main tank, preferably near the transformer marshalling box, for terminating cable connections from TCIV & detectors and for further connection to be control box. The degree of protection shall be IP55.

Cables

Fire survival cables (capable to withstand 750° C.) of 4 core x 1.5 sq. mm size for connection of detectors in parallel shall be used. The fire survival cable shall conform to BS 7629-1, BS 8434-1, BS 7629-1 and BS 5839-1, BS EN 50267-2-1 or relevant Indian standards.

Fire Retardant Low Smoke (FRLS) cable of adequate size shall be used for connection of signal box / marshalling box near transformer / reactor and FEC mounted near transformer/ reactor with control box mounted in control room.

Fire Retardant Low Smoke (FRLS) cable of 4 core x 1.5 sq. mm size shall be used for connection between control box to DC & AC supply source, FEC to AC supply source, signal box / marshalling box to transformer conservator isolation valve connection on transformer / reactor. Separate cables for AC supply & DC supply shall be used.

Pipes

Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.

Other items to be supplied.

(a) Oil drain and nitrogen injection openings with gate valves on transformer / reactor tank at suitable locations.

(b) Flanges between Buchholz relay and conservator tank for fixing TCIV.

(c) Detector brackets on transformer / reactor tank top cover.
(d) Spare potential free contacts activating the system i.e. in differential relay, Bucholz relay. Pressure Relief Device / RPRR, Circuit breaker of transformer / reactor.

(e) Pipe connections between transformer / reactor and FEC and between FEC and oil pit required for collecting top oil.

(f) Cabling for detectors mounted on transformer / reactor top cover.

(g) Inter cabling between signal box, control box and FEC.

(h) Butterfly valves / Gate valves on oil drain pipe and nitrogen injection pipe which should be able to withstand full vacuum.

(i) Supports, signal box etc. which are to be painted with enameled paint.

(j) Any other item required for satisfactory operation of system.

**Power supply**

For Control Box  220 V / 110 V DC

For FEC Auxiliary  230 V AC

**Spares for three (3) years Operation & Maintenance**

The bidder apart from the below mentioned spares shall submit a list of recommendation spares for three years trouble free operation of the equipments and also furnish unit rates. The owners will scrutinize the said list and decide on the items on spares to be ordered and the quantities. These spares shall be supplied by the contractor before end of guarantee period. The owner reserves right to order the spares with twelve (12) months from the date of order for main equipments and the rate shall be kept valid till this date. The prices of these spares shall not be considered for evaluation of the bid.

**Mandatory Spares**

Cylinder filled with Nitrogen of required Capacity per substation.  1 No.

Detectors per transformer  3 No.

Regulator assembly per sub-station  1 No.

**Modification on the transformer**
No modification on the transformer shall be allowed which affects its performance (i.e. efficiency, losses, heat dissipation ability etc.) safety, life etc. or it's any other useful parameter. This requirement shall be paramount importance and shall form the essence of the contract.

However, in any case, performance of transformer should not be affected in any manner by having Nitrogen Injection Fire Prevention Cum Extinguishing System (NIFPES) and the Contractor / Sub-Contractor shall give an undertaking to this effect. All pipes should be washed / rinsed with transformer oil. If any damage is done to the transformer and / or any connected equipment during installation & commissioning full recovery therefore shall be effected from the Contractor / Sub-Contractor, of NIFPES system.

It shall be solely the responsibility of Contractor / Sub-Contractor to install, carry out pre-commissioning tests & commission NIFPES at the mentioned Sub-Station in this specification, to the entire satisfaction of the GETCO.

**Interlocks**

It shall be ensured that once the NIFPES gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also PRV shall get closed only if all the connected breakers are open.
Tests

Contractor has to carry out the type test as per relevant IS/IEC. Specifically IP 55 on FEC or have to produce the report from NABL approved Lab. Reports of all routine test conducted as per relevant IS/IEC standards in respect of various bought out items including test reports for degree of protection for FEC / control box / signal box shall be submitted by the supplier.

The supplier shall demonstrate all the functional test associated with the following as Factory Acceptance Tests:

- FEC, Control Box
- Fire Detector
- Transformer Conservator Isolation Valve

The performance test of the complete system shall be carried out after erection of the system with transformer at site.

Detailed layout drawings, equipment drawing along with 4 sets of Operation and Maintenance manual along with soft copies (In CDs) shall be submitted by the supplier along with the consignment.

The guaranteed and other technical particulars for the offered system are indicated in Section - "Guaranteed and Other Technical Particulars". Any other particulars considered necessary in addition to those listed in that Section may be furnished by the Bidder.
GUARANTEED TECHNICAL PARTICULARS  
NITROGEN INJECTION SYSTEM FOR PREVENTION OF FIRE/EXPLOSION FOR TRANSFORMERS/REACTORS.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Guaranteed Particulars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Name of Manufacture and country of origin</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Reference standards</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Details of system equipments</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>FEC (Fire Extinguishing Cubicle)</strong></td>
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</tr>
<tr>
<td>4.1</td>
<td>Dimensions (LXBXH) mm</td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td>Weight</td>
<td></td>
</tr>
<tr>
<td>4.3</td>
<td>Capacity of Nitrogen cylinder</td>
<td></td>
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<tr>
<td>4.4</td>
<td>Number of cylinders</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>Pressure of Nitrogen filing</td>
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<tr>
<td>4.6</td>
<td>Minimum distance of FE cubicle from the transformer</td>
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</tr>
<tr>
<td>4.7</td>
<td>Method of mounting</td>
<td></td>
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<tr>
<td>4.8</td>
<td>Whether the following items are provided in FE cubicle. If so furnish make, type &amp; other details</td>
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<tr>
<td>4.9</td>
<td>Contact Manometer</td>
<td></td>
</tr>
<tr>
<td>4.10</td>
<td>Pressure Regulator</td>
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<tr>
<td>4.11</td>
<td>Oil Release Unit</td>
<td></td>
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<td>4.12</td>
<td>Gas release unit</td>
<td></td>
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<td>4.13</td>
<td>Oil drain assembly</td>
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<td>4.14</td>
<td>Pressure / limit switches</td>
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<td>No. of contacts &amp; spare contacts (NO &amp; NC)</td>
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<td>Oil drain Valve (ABOVE FEC)</td>
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<td>4.17</td>
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<td>4.18</td>
<td>Type</td>
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<td>4.19</td>
<td>Size</td>
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<td>Type of metal</td>
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<td>Nitrogen Injection Valve (Above FEC)</td>
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<td>Make</td>
<td></td>
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<td>4.23</td>
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<tr>
<td>4.24</td>
<td>Size</td>
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<td>Oil drain pipe</td>
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<td>4.26</td>
<td>Size</td>
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<tr>
<td>4.27</td>
<td>Length</td>
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<tr>
<td>4.28</td>
<td>Number of openings in the transformer tank</td>
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<tr>
<td>4.29</td>
<td>Material</td>
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<td>5</td>
<td><strong>Control Box</strong></td>
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<tr>
<td>5.1</td>
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<tr>
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<td>mm</td>
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<td>Type &amp; Thickness of sheet steel</td>
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<td>Details of components provided in the control box</td>
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<td>Control voltage</td>
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<td>5.6</td>
<td>Method of mounting</td>
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<td>5.7</td>
<td>Whether audio and visual alarm provided?</td>
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<td>6.</td>
<td><strong>Transformer Conservator Isolation Valve</strong></td>
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<td>Make</td>
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<td>6.2</td>
<td>Type</td>
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<tr>
<td>6.3</td>
<td>Location</td>
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<td>6.4</td>
<td>Whether suitable for pipe of size 80 mm dia</td>
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<td>No. of contacts &amp; spare contacts (NO &amp; NC)</td>
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<td>6.6</td>
<td>Padlocking provision</td>
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<td>7.</td>
<td><strong>Detectors</strong></td>
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</tr>
<tr>
<td>7.1</td>
<td>Make</td>
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<td>7.2</td>
<td>Type</td>
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</tr>
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<td>Quantity required</td>
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<td>7.4</td>
<td>Method of fixing</td>
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<td>7.5</td>
<td>Effective heat sensing area</td>
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<td>7.6</td>
<td>Temperature recommended for effective heat sensing</td>
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<td>7.7</td>
<td>Number of contacts NO / NC</td>
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<td>7.8</td>
<td>Necessity and condition of Refilling</td>
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<td>8.</td>
<td>Whether approved by Tariff Advisory Committee of India</td>
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<td>9.</td>
<td><strong>TECHNICAL PARTICULARS FOR NITROGEN INJECTION SYSTEM FOR PREVENTION OF TRANSFORMER EXPLOSION</strong></td>
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<tr>
<td>10.</td>
<td><strong>Power Supply</strong></td>
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<td>10.1</td>
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<td>10.2</td>
<td>FEC (lighting)</td>
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<tr>
<td>10.3</td>
<td>Extinction period</td>
<td></td>
</tr>
<tr>
<td>10.4</td>
<td>On system activation</td>
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<td>On commencement of Nitrogen injection</td>
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<td>FEC Suitable for capacity</td>
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<td>11.2</td>
<td>Weight</td>
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<td>11.3</td>
<td>Nitrogen cylinder capacity</td>
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<td>12.2</td>
<td>Weight</td>
<td></td>
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<tr>
<td>13.</td>
<td><strong>Detectors</strong></td>
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<td>Heat sensing temperature</td>
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13.2 Time of Operation

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<tr>
<th></th>
<th>Transformer Tank Explosion Prevention</th>
<th>Fire Extinction</th>
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<tbody>
<tr>
<td>a. For system activation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. For reduction of pressure in Tank by Nitrogen release.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13.3 Any other technical details not covered above.