

# **DAMODAR VALLEY CORPORATION**

**ENGINEERING DEPARTMENT**

**DVC TOWERS, VIP ROAD**

**KOLKATA – 700054**



**TECHNICAL SPECIFICATION**

**FOR**

**200 MVA, 230/138/33 KV AUTO TRANSFORMER  
WITH UNLOADED TERTIARY**



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## **TECHNICAL SPECIFICATION FOR 200 MVA ATR WITH ASSOCIATED EQUIPMENT:**

### **1.0 GENERAL CONDITIONS OF CONTRACT**

The attached DVC's General Conditions of Contract (GCC) forms a part of this tender specification and shall govern the purchase of equipment and services as specified herein. However, in case of any conflict between GCC and this specification, the latter shall prevail.

### **2.0 SCOPE**

This specification covers the design, manufacture, assembly, testing at manufacturer's works and delivery FOR destination at the site of DVC (details provided at Annexure 'A') for –

200 MVA, 230/138KV/33KV, 50Hz, YNa0d1, Unloaded Tertiary, Core type, 3 phase, outdoor type, oil immersed, ONAN/ONAF/OFAF cooled Auto Transformer complete with Main tank, separately mounted Cooler bank, OLTC suitable for voltage variation of +/- 10% in steps of 1.25%, CC cubicle, digital RTCC panel, Condition controlled Regenerative maintenance free Silica Gel breather for Main & OLTC Conservator, CC cabinet, terminal connectors and all other fittings & accessories (including mandatory spares) and transformer oil for 1st filling plus 10% extra along with complete set of equipment for Fire Prevention & Extinguishing System by Nitrogen Injection method as per technical spec. including supply of all control units, fittings & accessories, pipe, connectors, required control cables, AC/DC converters etc. all complete along with supply of spare N<sub>2</sub> cylinder for above transformer, complete sets of Fiber Optic Temperature Sensors, Online DGA & moisture content monitoring system and On-line insulating oil drying system (Cartridge type).

Supply of foundation bolts with nuts will be within the scope of the transformer supplier.

Local cabling from transformers and radiator mounted devices up to Marshalling Kiosk/cooler control cubicle / OLTC etc., for local control will be within the scope of transformer supplier.



Scope shall also include design, manufacture, testing at manufacturer's works, supply, delivery FOR site including unloading on the respective plinths /suitable place at site as per direction of Site Engineer In charge / Consignee, adequately packed for Road Transportation of 'Mandatory Spares & Special Tools & Tackles' as listed in the Schedule – II/A of this specification.

The scope of work may include, at the option of the purchaser total erection and Commissioning of transformers at site. The lump sum erection and commissioning charges along with terms and conditions shall be stipulated clearly in the relevant schedule of the specification.

Any material and equipment not specifically stated in this specification, but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost implication.

Supervision charges on daily basis for deputing Engineers/Technicians for the purpose of supervising erection & commissioning per day shall also be stipulated clearly in the relevant price schedule of the NIT specification.

**This supervision charges shall remain valid up to delivery completion period plus one (1) year.**

### 3.0 BASIS OF DESIGN

3.01 The Auto Transformer will be used to connect the 220KV system with 132KV system. The auto transformer shall be used for bi-directional flow of rated power. The auto-transformer shall in general have constant ohmic impedance between HV and IV on all taps. External or internal reactors shall not be used to achieve the HV/LV and IV/LV impedance specified.

3.02 The transformer will be installed in hot, humid and tropical atmosphere. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

3.03 The transformer shall be capable of continuous operation at rated output under the following condition:

a. Voltage variation :  $\pm 10\%$



- b. Frequency variation :  $\pm 3\%$   
c. Combined voltage and frequency variation (absolute sum) :  $10\%$

The transformers shall be capable of being operated, without danger, on any tapping at the rated MVA with voltage variation of  $\pm 10\%$  corresponding to the voltage of the tapping.

- 3.04 The transformer and all its accessories including CTs etc. shall be designed to withstanding the short circuit stresses due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.
- 3.05 The transformer shall be free from annoying hum or vibration. The design shall be such as not to cause any undesirable interference with radio or communication circuits. The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.
- 3.06 The noise level of transformer, when energized at normal voltage and frequency with fans and pumps running shall not exceed, when measured under standard conditions, the values specified at relevant clause. The noise level shall be limited to the value specified by NEMA Standard Publication No. TR-1-1993 when measured in accordance with conditions outlines in ANSI/IEEE C57.12.90-1999/IS13964/CBIP publication.
- 3.07 The tertiary shall be suitable for no-load operation. Winding / core shall be designed to achieve specified properties without use of any external surge capacitors or reactors. The tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals.

#### 4.0 EQUIPMENT REQUIRED

The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. Adequate safety margin w.r.t. Thermal, Mechanical, Dielectric and Electrical stress etc. shall be maintained during design,



selection of raw material, manufacturing process etc. in order to achieve long life of transformer with least maintenance. The equipment to be supplied under this specification is indicated below. The 'Design Criteria' for the following transformers shall be guided by 'Annexure-D' of this specification.

Equipment Details:	Quantity
<p>i) 200 MVA, 230 KV/ 138KV/ 33KV, 50Hz YNa0d11, Unloaded tertiary, Core type, 3-phase, outdoor type, Oil immersed, ONAN / ONAF / OFAF cooled Auto-Transformer complete with Main tank, separately mounted cooler bank, OLTC suitable for voltage variation of <math>\pm 10\%</math> in steps of 1.25%, digital RTCC Panel, Condition controlled Regenerative maintenance free Silica Gel breather for Main &amp; OLTC Conservator, CC cabinet, terminal connectors and all other fittings &amp; accessories, spares.</p> <p>The above transformer shall be complete with all necessary, applicable fittings, accessories, auxiliaries and devices including but not limited to those specified against clause no. 9 of this specification.</p> <p>The transformer shall be complete with oil for first filling plus 10% extra.</p>	4 (Four) Nos.
<p>ii) Complete set of equipment for Fire Prevention &amp; Extinguishing System by Nitrogen (N<sub>2</sub>) Injection method as per technical specification including supply of all control units &amp; accessories, pipe, connectors, required control cables, AC / DC converters etc. all complete along with supply of spare N<sub>2</sub> cylinder for above Transformer.</p>	4 (Four) Sets
<p>iii) Fiber Optic Temperature Sensors with its monitor, accessories, software, etc. as per technical specification for above transformer.</p>	4 (Four) Sets
<p>iv) Online DGA &amp; Moisture content monitor complete with all accessories &amp; software as per technical Specification for above transformer.</p>	4 (Four) Sets



v) Online insulating oil drying system (Cartridge type)
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4 (Four) Sets
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## 5.0 GENERAL SITE INFORMATION

The general site information shall be as per 'Annexure - A' of this specification.

## 6.0 REFERENCE STANDARDS

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable IEC and IS except where modified and/or supplemented by this specification.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

The relevant IS/IEC/other applicable standards have been furnished in 'Annexure-'F' of this specification.

## 7.0 PERFORMANCE

7.01 Transformers shall be capable of operating under natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially as ONAF up to specified load and then as OFAF. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140<sup>0</sup>C. If the Transformer is fitted with two cooler banks, each capable of dissipating 50 per cent of the loss at continuous maximum rating, it shall be capable of operating for 20 minutes at full load/ continuous maximum rating in the event of failure of the oil circulating pump or fans/blowers





associated with one cooler bank without the calculated winding hot spot temperature exceeding 140°C. The successful bidder may be required to submit supporting calculations for the above during detailed design review.

- 7.02 The transformer shall be free from any Electrostatic Charging Tendency (ECT) under all operating conditions and maximum oil velocity shall be such that it does not lead to static discharges inside the transformer while all coolers (including spare) are in operation.
- 7.03 The transformers shall be capable of being continuously operated at the rated MVA without danger, at any tapping with voltage variation of  $\pm 10\%$  corresponding to the voltage of that tapping.
- 7.04 The transformers shall be capable of being overloaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.
- 7.05 The hotspot temperature in any location of the tank shall not exceed 110°C at rated MVA. This shall be measured during temperature rise test at manufacturer's works.
- 7.06 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 % continuous over-voltage condition it does not exceed **1.9 Tesla** at all tap positions.
- 7.07 The transformer and all its accessories including bushing / built in CTs etc. shall be designed to withstand without damage, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding. The transformer shall be designed to withstand the thermal stress for short circuit duration of 2 seconds and the same shall be verified during design review.
- 7.08 Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any terminals. Mechanical strength of the transformer shall be such that it can withstand 3-phase and 1- phase through fault for transformer rated voltage applied to HV and/or IV terminals of transformer. The short circuit shall alternatively be considered to be applied to each of the HV, IV and LV transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the



transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered.

- 7.09 Transformers shall withstand without damage, heating due to the combined voltage and frequency fluctuations which produce the following over fluxing conditions:

110 % for continuous

125 % for 1 minute

140 % for 5 seconds

Withstand time for 150% & 170% over voltage shall be indicated. Over fluxing characteristics up to 170 % shall be submitted.

- 7.10 Radio Interference and Noise Level - The transformer shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.

The noise level of transformer, when energized at normal voltage and frequency with fans and pumps running shall not exceed the specified values, when measured under standard conditions.

## 8.0 AUX. SUPPLY SYSTEM DATA

The auxiliary supply system data shall be as indicated in the 'Annexure-B' of this specification.

## 9.0 GENERAL FITTINGS REQUIRED FOR TRANSFORMER

- 9.01 Air cell bag type conservator along with its supporting bracket to be mounted on independent structures mounting & the structure shall be within the scope of transformer supplier. Main conservator shall have air cell type constant oil pressure system to prevent oxidation as well as contamination of oil due to contact with moisture. The conservator tank shall have adequate capacity with highest and lowest visible level to meet the requirement of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to top Oil Temperature of 100 deg. C. Suitable provision to be kept for replacement of Air Cell and cleaning of Conservator as applicable. The conservator shall be fitted with lifting lugs in



such a position so that it can be removed for cleaning purposes. Suitable provision is to be kept for replacement of Air cell and cleaning of Conservator, as applicable. Connection of air cell to the top of the conservator shall be ensured by air proof seal preventing entry of air into the conservator. Relay at the top of conservator shall be fitted to give alarm to indicate failure of air cell bladder. The Conservator tank and piping shall be designed for complete vacuum / filling of main tank & Conservator Tank. Provision must be made for equalizing the pressure in the Conservator Tank and Air cell during vacuum / filling operations to prevent rupturing of Air Cell.

The temperature of oil in the conservator is likely to rise up to 100 deg C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

The conservator shall be positioned in such a way that the conservator and its pipe work do not obstruct any electrical connection to transformer and removal of tap changers for maintenance or opening of inspection covers.

The conservator pipe shall rise towards the main conservator, through Buchholz relay, at an angle of not less than 3 degrees.

- 9.02 Conservator filling hole with cap (removable)
- 9.03 Conservator drain valve with flanged pipe terminal.
- 9.04 Isolating valve for conservator / Buchholz relay.
- 9.05 OLTC conservator Drain valve
- 9.06 OLTC Conservator Isolating valve
- 9.07 Prismatic oil level gauge for Main tank & OLTC conservator. OLTC shall have conventional type conservator (without air cell) with prismatic oil level gauge and magnetic oil level indicator with two sets of potential free low level alarm contacts.
- 9.08 Buchholz relay for main tank having double float type with two sets of contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. Contacts shall be suitable for minimum one ampere current rating at  $220 \pm 10\%$  V. DC. The relay contacts shall be wired up to the outgoing terminal block of marshalling kiosk. Shut off valves shall be provided on both sides of the Buchholz relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for



checking its operation and taking gas sample. A copper / stainless steel tube shall be connected from the gas collector to a valve located about 1400mm above ground to facilitate collection / sampling of gas while transformer is in service. Buchholz relay shall be type tested as per IS: 3637. Buchholz relay and its terminal box shall conform to IP55 degree of protection. Oil surge relay for OLTC shall have trip contact which shall be wired up to the outgoing terminal block of Marshalling Kiosk.

Oil surge relay for OLTC shall have trip contact which shall be wired up to the outgoing terminal block of Marshalling Kiosk.

- 9.09 Oil filling hole with cap on OLTC Conservator.
- 9.10 Condition controlled Regenerative maintenance free Silica Gel breather for Main & OLTC Conservator.
- 9.11 Magnetic oil level gauge with minimum two (2) sets of alarm contacts (for remote annunciation) on one side and built-in oil level coloured gauge (with minimum level marking) on the other side of the Main conservator. Current rating of alarm contacts shall be 1 (one) amp. At 220 V  $\pm$  10% D.C. contacts are to be wired up to the marshalling kiosk outgoing terminal block.
- 9.12 Three (3) nos. silica gel breathers (of identical size), with oil seals and connecting pipes and valves, shall be connected in series for Main tank conservator. Also, to minimize ingress of moisture, two (2) nos. silica gel breathers (of identical size), with oil seals and connecting pipes and valves shall be connected to OLTC conservator. Each silica gel breather shall be of 100% capacity & shall have the facility of removal after closing of isolating valves when the transformer is in operation.
- 9.13 **Pressure relief device (PRD)** at least 2 nos. with self-sealing arrangement and oil collecting device to be provided. Pressure relief device, shall have sufficient size for rapid release of any pressure that may be generated inside transformer tank without damage to the transformer, shall be provided at suitable locations directly on the tank. These PRD shall operate at a static pressure less than the hydraulic test pressure of the transformer tank. Proper provision shall be provided for taking discharge of PRD to a place away from transformer through pipes etc. thus preventing spray on



the tank , which may result in damage to equipment. Oil discharge should be kept away from control cubicle and clear of any operating position to avoid injury to personnel in the event of PRD operation. One set of electrically insulated contacts shall be provided for Alarm / tripping.

Following 'Routine test' shall be conducted on the PRD and submitted to DVC –

- i) Air pressure test.
- ii) Liquid pressure test.
- iii) Leakage test.
- iv) Dielectric & Contact test.

- 9.14 One Sudden Pressure Relay (for 220KV and above Transformer) with necessary alarm or trip contact (preferably terminal connection plug & socket type arrangement) shall be provided on tank of the transformer. Operating features and size shall be reviewed during detailed engineering stage. Suitable canopy shall be provided to prevent ingress of rainwater. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay.
- 9.15 For oil conservator oil head, if required, at the HV/IV/LV bushing ends oil pressure shall maintain Seal arrangements. The oil connections shall however be tapped from the tank to conservator oil piping on the tank and on the lower side of the Buchholz relay through suitable isolating valves.
- 9.16 Inspection covers / access holes on tank cover and tank, with bolted covers for access to inner ends of the bushings, on-load-tap changing gear, and oil immersed current transformers for winding temperature indicator etc. (i.e. areas required for inspection).
- 9.17 Lifting eyes for cover only.
- 9.18 Lifting eyes for core and winding.
- 9.19 Lifting lugs for whole transformer.
- 9.20 Jacking pads with hauling hole.
- 9.21 Skid arrangement welded with tank base.
- 9.22 Transport lugs with hauling holes.
- 9.23 Locking arrangement (Yoke Clamp Assy. With tank cover).



- 9.24 Air release plugs at the top of cover and bushing turrets.
- 9.25 Upper filter valve (50mm dia) suitably baffled to reduce aeration of oil, flanged to seal 35mm IPS threaded adopter (for oil filter m/c pipe connection).
- 9.26 Bottom filter valve (50mm dia) flanged to seal 35mm IPS threaded adopter (for oil filter m/c pipe connection).
- 9.27 Drain valve (100mm dia) flanged and 15mm dia oil sampling valve.
- 9.28 Under carriage with flanged bi-directional wheels for rail gauge along the major and minor axis of the Transformers is indicated in Annexure – D (Design Criteria).
- 9.29 Drain plug on Tank (1" BSP).
- 9.30 Tank & A-Frame earthing terminals – minimum two (2) nos. each.
- 9.31 Ladder with safety device for inspection and testing of Buchholz relay and other tank mounted devices.
- 9.32 Pocket at suitable places for inserting alcohol thermometer for oil temperature indication along with necessary alcohol thermometer.
- 9.33 Pocket for WTI.
- 9.34 Pocket for OTI with thermometer.
- 9.35 Pocket for RTD.
- 9.36 Oil surge relay for OLTC shall have trip contact of minimum one (1) ampere current rating at 220 V  $\pm 10\%$  DC and which shall be wired up to the outgoing terminal block of Marshalling Kiosk.
- 9.37 A device for measuring the hot spot temperature of each winding shall be provided (HV & IV). It shall comprise of the following:  
Winding temperature (Hot spot) indicating devices complete with current transformers, heater elements bellow resistance Arm Bridge, rectifier unit etc. as required with local dial thermometer and one no. remote indicator suitable for flush mounting on remote control panel and will operate by signal transmitter. The local dial thermometer located in the transformer marshalling kiosk shall have at least two (2) sets of trip and one (1) set of alarm contacts other than those required for cooler control. The setting of alarm and tripping contacts shall be adjustable at site. The contact rating shall be minimum one (1) amp. At 220 V  $\pm 10\%$  D.C. The W.T.I. contact



along with connections required for remote repeater dial shall be wired up to the Marshalling Kiosk outgoing terminal block. In addition to the above, the following equipment shall be provided for remote indication of winding temperature:

- i) **Signal Transmitter**: Signal transmitter shall have additional facilities to transmit signal for recording winding temperature at Data Acquisition System. For this purpose a separate duplex Platinum RTD with nominal resistance as per SAMA (USA) standard shall be placed in the pocket containing temperature sensing element and image coil for WTI system which will be used both for Remote WTI and DAS/SCADA. It shall provide dual output 4-20mA for SCADA/SAS system. All necessary equipment required for sending the signal to remote WTI & DAS/SCADA shall be provided.
- ii) **Remote Winding Temperature Indicator**: It shall be suitable for flush mounting on digital RTCC Panel and will operate by signal transmitter. One no RWTI each shall be provided for all the windings (HV & IV).

Any special cable required for shielding purpose, for connection between Marshalling box / Cooler Control Cabinet and Remote WTI, shall be in the scope of the Bidder. The bidder shall furnish the GTP of this special cable during detail engineering. The approximate distance from Marshalling kiosk to Remote Tap Changer Control Panel may be considered as 500 Mtr. WTI (Local & Remote) shall be provided both for HV winding & IV winding (one each).

9.38 CT terminal box on HV & IV turret for (WTI & RTD).

9.39 Dial thermometer for oil temperature indication complete with two (2) sets of trip and one (1) set of alarm contacts. The contacts rating shall be minimum one (1) ampere at 220 V  $\pm$  10% DC. The dial thermometer shall be located in the Marshalling Kiosk. The contacts shall be wired up to the Marshalling Kiosk of outgoing terminal block. In addition to the above, the following equipment shall be provided for remote indication of oil temperature:

- i) **Signal Transmitter**: Signal transmitter shall have additional facilities to transmit signal for recording oil temperature at Data Acquisition System. For this purpose a separate duplex Platinum RTD with nominal resistance as per SAMA (USA) standard shall be



placed in the pocket containing temperature sensing element and image coil for OTI system which will be used both for Remote OTI and DAS/SCADA. It shall provide dual output 4-20mA for SCADA/SAS system. All necessary equipment required for sending the signal to remote OTI & DAS shall be provided.

- ii) **Remote Oil Temperature Indicator:** It shall be suitable for flush mounting on digital RTCC Panel and will operate by signal transmitter.

**Any special cable required for shielding purpose, for connection between Marshalling box / Cooler Control Cabinet and Remote OTI, shall be in the scope of the Bidder.** The bidder shall furnish the GTP of this special cable during detail engineering. The approximate distance from Marshalling kiosk to Remote Tap Changer Control Panel may be considered as 500 Mtr.

The WTI and OTI devices shall have range of temperature of about 0-150°C with accuracy of  $\pm 1^\circ\text{C}$  or better. The thermometers shall have adjustable, potential free alarm and trip contacts, instrument shall be provided with maximum reading pointer and resetting device, switch testing knob & anti-vibration mounting grommets (for projection mounting) as applicable. The instruments case should be weather proof and epoxy coating at all sides. Instruments should meet ingress protection class of IP55 or better. Temperature indicator dials of OTI shall have linear gradations to clearly read at least every 2 deg C. The setting of alarm and tripping contacts for WTI & OTI shall be adjustable at site. Also, suitable accessories like temperature transducer with sensors (PT100 or better and calibrated as per relevant IEC/IS) shall be provided for remote indication of each winding temperature and oil temperature. The RTDs shall include image coil for OTI & WTI system (along-with aux. CTs if required to match the image coil for WTI system) and shall provide dual output 4-20mA for remote temperature Indication and SCADA system individually. The transducers (and aux. CT for WTI) shall be installed in the individual Marshalling Box. Any special cable required for shielding purpose, for connection between respective temperature sensor and transducer, shall be in the scope of manufacturer. 4-20mA signal shall be wired to digital RTCC panel / BCU panel for further transfer data to SCADA through IEC 61850 compliant communications.

9.40 Rating plate and Diagram plate as per IEC/IS 2026 and also danger plate.

9.41 For transformer, on-load-tap changing gear on H.V. winding for a voltage variation range of  $\pm 10\%$  (ten percent) in steps of 1.25 % (percent), total no. of taps shall be 17





(seventeen) nos. including normal tap. Tap changer shall be suitable for operation locally and also from remote tap changer panel. In addition to local tap position indicator, remote tap position indicator shall also be supplied in remote tap changer panel. OLTC shall be suitable for both independent & master follower operation. OLTC shall have separate oil chamber / conservator with oil surge relay and oil level gauge.

- 9.42 Marshalling Kiosk for mounting of local indicating instruments and terminal connections for all transformer mounted equipment relays & devices. Marshalling Kiosk shall have degree of protection IP 55 (weatherproof) or better, by enclosure with sheet steel (CRCA) thickness of 2.5 mm (Min.).

The temperature indicators shall be so mounted that the dials are at sufficient height from the ground level for convenience of reading and glazed door of suitable size shall be provided.

- 9.43 OLTC local control cabinet- OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with 4-20mA transducer dual outputs for tap position indication in Marshalling Box and input to digital RTCC/relevant BCU (as applicable for SAS)/ SCADA system. The tap position indicator shall also be provided in control room. The OLTC control schemes equipment along with local control and indicating devices as per purchaser's approved scheme shall be provided in LCC. The LCC shall be designed for IP 55 (weatherproof) degree of protection or better by enclosure with sheet steel (CRCA) thickness of 2.5 mm (Min.).

9.44 **COOLING EQUIPMENT**

Design of cooling system shall satisfy the performance requirements of respective Transformer. The main tank shall have provision such that cooler banks can be placed on either side of the main tank by simple reconnection without the need of any extra member/pipe maintaining the electrical clearances. Separately mounted (but compact as far as practicable) pressed steel radiator stacks (necessary supporting structures shall be within the scope of the transformer supplier / manufacturer) having two



(each of 50%) radiator stacks shall be complete with following fittings: -

- i) Oil service valves (25mm dia) on the Transformer tank, one in the top head and other in the bottom header flanged for bolted connection to the radiator stack. Each radiator fin shall be detachable from top and bottom header and connected to headers through shut off valves.
- ii) One oil drain plug in the radiator and its pipe work including ( $\frac{3}{4}$ " BSP) bottom header of the radiator stack.
- iii) Lifting lugs for the stack.
- iv) Air release plugs in the top header & bottom header.
- v) Thermometer pocket on top & bottom header.
- vi) Oil inlet and outlet valves (150mm dia.).
- vii) Filter valves (25mm dia) on pipe works.
- viii) AC motor driven cooling fans/ blowers built on the radiator stacks. [The motors shall be preferably squirrel cage induction motor, suitable for  $415 \pm 10\%$  V, 3ph,  $50 \pm 3\%$  Hz AC supply for both fan & pump]. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.
- ix) Oil pump and motor.
- x) Necessary oil strainers.
- xi) Oil service pipelines with steel supports, if required.
- xii) Wheels for hand operation with all valves.
- xiii) Oil flow indicators each with two sets of contacts for alarm and remote indication of stoppage of oil flow.
- xiv) For Transformer cooler control panel – Outdoor cooler control cabinet (IP55 or better weather proof degree of protection) for housing control, protection and indicating devices for above cooling fans or blowers as per purchaser's approved scheme. The facility shall be, therefore, normal and auto-change over of duplicate A.C. supplies (415V, 3-phase) manual and auto-control of fans & pumps. Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS 325. There shall also be facility of both local and remote control and indication. Necessary potential free contacts of



rating 1(one) ampere at 220V  $\pm$  10% D.C shall be provided for annunciating all the fault conditions of cooling system as a whole in remote tap changer control panel (separate cooler control cabinet may not be required if all the equipment required for the purpose are accommodated in the marshalling Kiosk). Each cooling fan and oil pump motor shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Cooling fan and oil pump motors shall have hose proof enclosure equivalent to IP55 or better.

Cooler control panel shall be of 2.5 mm (min.) thick sheet steel (CRCA) as per IS 513. Frame, load bearing support / structure, relay / meter etc. mounted sheet shall be 2.5 / 3mm sheet steel (CRCA). Front door may be glass with steel frame- as per approved drawing. All access doors shall be provided with channel rubber/neoprene gaskets all around. Cooler control panel shall be protection class of IP55 for outdoor installation.

- xv) Required number of standby fans of adequate capacity shall also be provided in addition to the main fans with each radiator bank.
- xvi) Two (2), 100% online oil pumps (out of which one pump shall be standby) shall be provided with each radiator bank.

Measure shall be taken to prevent mal-operation of Buchholz relay when both oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

Design of cooling system shall satisfy the performance requirements.

- 9.45 Gas pressure cylinder with testing valve and pressure gauge shall be provided during transportation if the transformer is shipped filled with inert/N<sub>2</sub> gas.
- 9.46 Neutral bushing current transformers as per details given in "Annexure-D" of this specification. The CTs shall be housed in weatherproof enclosure with suitable terminal boxes. The arrangement shall be such that the CT can be removed from the transformer without removing tank cover. Necessary precautions shall be taken to



minimize eddy current and local heat generated in the turret. The CT terminal shall be wired up to Marshalling Kiosk terminal box terminals with proper heat resistant cables. Each CT lead shall be wired up to Marshalling Kiosk through two nos. 2.5 mm<sup>2</sup> copper conductors (FRLS type) cabling.

9.47 CT terminal Box tank wall for HV-n Housing.

9.48 Neutral Earthing Arrangement: High voltage winding neutral shall be brought out through top cover mounted bushing. Two ground conductors 50mm X 6mm Galvanized steel flats shall run from neutral bushing to the bottom of the tank for connection to station ground. These shall be mounted on Post insulators having voltage grade that of neutral bushing.

36 KV Post Insulator of approved type, size and make shall be used for bringing down the HV/IV-N. G.I. Flat up to 200mm above the ground level for earthing.

9.49 25 NB OLTC suction pipe should be brought down to the man height level.

9.50 OLTC Head earthing Arrangement.

9.51 All alarm / relaying contacts to be provided by the tenderer in addition to those mentioned here shall be suitable for 220 V  $\pm$  10% D.C. as per scheme requirement. If the ratings do not meet this requirement; the tenderer shall supply reliable auxiliary contactor / relays to meet the purchaser's requirement.

9.52 100% percent output from the transformer shall be ensured even if one cooler pump and one fan of each bank (of 50% radiator stacks) are out of service.

9.53 **Terminal Arrangement**

The physical position of the terminals and the markings shall be as per relevant IS/IEC unless otherwise required to suit the layout. HV, IV & LV terminals of interconnecting transformer shall be brought out thru' top cover mounted bushings for connection to purchaser's overhead ACSR / AAAC Conductor / Aluminium tube bus.

Termination arrangement for transformer shall be as specified in "Annexure-D" of this specification. Expansion type terminal connector suitable both for horizontal & vertical take-off for HV, IV, HV-n bushings to be connected to purchaser's ACSR Conductor / 2.5" IPS Al Tube (for HV & IV) , etc.

Bushing terminals (HV & IV) shall be provided with terminal connectors of approved



make for connection to external parts. Bi-metallic strip shall be provided wherever required to avoid contacts between dissimilar metals.

**Note:** However, terminal arrangement may be finalized during detail engineering.

#### 9.54 Bushings

- i) Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement of transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval.
- ii) Bushing for voltage of 52 kV and above, shall be RIP (Resin Impregnated paper) condenser type bushing with composite Polymer insulator (housing). However, suitable RIS (Resin Impregnated Synthetic) condenser type bushing with composite polymer insulator housing, satisfying Technical Specification requirements, may also be acceptable. 36 kV bushing shall be Antifog type, fully weather proof, solid or oil communicating type with porcelain housing.
- iii) RIP type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.
- iv) Tan  $\delta$  value of RIP bushing shall be 0.005 (max.) in the temperature range of 20 deg C to 90 deg C. The measured Tan  $\delta$  value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results (measured at approx. similar temperature conditions) during warranty period.
- v) Where current transformers are specified, the bushings shall be removable without disturbing the current transformers. **Bushings of identical rating shall be interchangeable** to optimise the requirement of spares.
- vi) Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.
- vii) Polymer / composite insulator shall be seamless sheath of a silicone rubber compound.



The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP. The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of withstanding high pressure washing.

- viii) End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.
- ix) The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test).
- x) Clamps and fittings shall be of hot dip galvanised/stainless steel. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay. No arcing horns shall be provided on the bushings.



- xi) Spare Bushing shall be specially rotten free packed suitable for long storage with non-returnable packing, wooden boxes with hinged type cover, without any gap between wooden planks. The details of which shall be provided to the purchaser. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

Oil end portion of RIP/RIS type bushings shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact of moisture with epoxy. The pressure of dry air needs to be maintained in case of leakage.

- xii) The terminal marking and their physical position shall be as per IEC: 60076.
- xiii) Bushing location shall provide adequate phase and ground clearances. Installation procedures for various voltage class bushings shall be clearly brought out in the instruction manual.
- xiv) Bushing shall conform to Annexure-M of Standard Specifications and technical Parameters for Transformers and Reactors (66 kV & above voltage class).

#### 9.55 **Lightning Arrester Mounting Arrangement**

On HV & IV side Lightning Arresters will be mounted separately on Purchaser's structure. The recommended distance between transformer & LA may please be indicated by the supplier. (LA's are not under the scope of transformer supplier).

#### 9.56 **Remote Tap Changer Panel**

- i) Exterior – Light grey to shade No. 631 of IS 5 of Semi-Gloss.
- ii) Interior – White Enamel Gloss.
- iii) Degree of protection IP52 or better.
- iv) Material – 2 mm (min.) thick sheet steel (CRCA) as per IS 513. However, the Frame, load bearing support/structure, relay/meter etc. mounted sheet shall be 2.5 / 3mm sheet steel (CRCA). Front door may be glass with steel frame -- as per approved drawing. All access doors shall be provided with channel rubber/neoprene gaskets.



- v) All power supply fuses and link terminals are to be shrouded.
- vi) Panel wiring shall be done with PVC 2.5 mm<sup>2</sup> copper wire of 1.1 KV grade.
- vii) The digital RTCC Panel shall house actuating switch for electrical raise/lower control, tap position indicator, signal lamps for 'Tap Change in progress' and 'Tap Changer out of step' etc. and all other auxiliary devices for remote electrical control of the OLTC.
- viii) For remote tap position indicator, the dual output type OLTC transducer shall be provided in the digital RTCC panel. One of the outputs of this transducer shall be used for local indication of tap position in digital RTCC panel and other output (4-20mA) shall be used for RTUs/SCADA system.

For remote OTI & WTI, the dual output type transducer shall be provided separately in the digital RTCC panel. One each of the output of this transducer shall be used for Remote OTI and Remote WTI in digital RTCC panel and other output (4-20mA) shall be used for RTUs/SCADA system.

- ix) Provision shall be made for remote control and monitoring of OLTC. Remote operation shall be possible from Automatic transformer tap changer cum monitoring IEDs mounted in Transformer RTCC panel over IEC 61850 protocol. RTCC shall be digital RTCC (Numerical Relay based control and monitoring & SCADA enabled) as per relevant IS/IEC Standard.

Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-built large LCD (or better) display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer/location, it could be customized to suit site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT/VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.

It shall be possible to communicate/integrate with all digital RTCC relays of different





make located at different locations in the substation by making hardwire and using IS/IEC 61850 communication link. The integration of existing conventional RTCC panel with digital RTCC panel of different make shall also be possible.

The digital RTCC relay shall have Raise/Lower push buttons, Manual/ Automatic mode selection feature, Local/Remote selection feature, Master / Follower/ Independent/ Off mode selection feature for control of OLTC. Touch screen option in the relay (instead of electrical push button/switch) is also acceptable.

Digital RTCC relays shall communicate with SCADA using IEC 61850 through fibre optic port to monitor, parameterize and control the OLTC. Any software required for this purpose shall be supplied and commissioned. The supplied software shall not have restriction in loading on multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time.

The Digital RTCC relay shall have additional programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for future use. It shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement.

I/Os from/to SCADA for annunciation, control & monitoring of the transformers, as indicated here are minimum and indicative. The bidder shall indicate in the offer any other I/Os, if necessary, for satisfactory operation of the equipment. However, the Purchaser shall approve the same.

#### **SCADA I/O:**

The bidder shall consider following I/O to be communicated to SCADA in addition to conventional alarm system.

- a. Oil temp High – Alarm
- b. Oil temp High – Trip



- c. Oil temp normal - Indication
- d. Winding Temp High – Alarm (HV & LV)
- e. Winding temp High –Trip (HV & LV)
- f. Winding Temp Normal – Indication
- g. Dissolved Gas High – Alarm (if applicable)
- h. Dissolved Gas High – Alarm (if applicable)
- i. Dissolved Gas Analyser Fail – Alarm (if applicable).
- j. Buchholz Relay – Alarm
- k. Buchholz Relay – Trip
- l. Pressure Relief device operated for both PRD device (Main tank)
- m. Pressure Relief device operated for PRD device (OLTC)
- n. Oil surge relay operated for OLTC
- o. OLTC circuit healthy
- p. OLTC in progress.
- q. OLTC failed to operate.
- r. OLTC motor tripped.
- s. OLTC AC Supply Fail
- t. OLTC Local / Remote selector switch position.
- u. OLTC Out of Step Indication
- v. OLTC Mechanism Stuck up
- w. OLTC upper limit reached.
- x. OLTC lower limit reached.
- y. OLTC Operation Auto Mode
- z. Tap position on 'N'
- aa. Transformer –N is master.
- ab. NIFPS operated.

The bidder shall consider following **Analog Inputs (4-20mA)** to be communicated to SCADA.

- a. Tap position indication



- b. HV Winding Temperature indication.
  - c. LV Winding Temperature indication
  - d. Oil Temperature indication.
- x) 50 x 6 mm GI/GS flat ground bus shall be provided on the panel extending along the entire length of the assembly. The ground bus shall have two-bolt drilling with GI bolts and nuts at each end to receive Owner/Purchaser's ground connection.

#### 9.57 **Earthing Terminals**

Two earthing pads [each complete with two (2) nos. holes, bolts, plain and spring washers] suitable for connection to 50 × 6 mm / 75 × 12 mm galvanized steel grounding flat, located on the diagonally opposite sides of the transformer tank, shall be provided for connection to station ground mat.

Two earthing terminals suitable for connection to 50 × 6 mm / 75 × 12 mm galvanised steel flat shall also be provided on each cooler, individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/Online DGA/Optical Sensor Box etc., (if provided), double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper link.

Ground terminals shall also be provided on coolers, marshalling boxes, digital RTCC and any other equipment mounted separately to ensure its effective earthing.

For continuity of earth connection, all gasketed joints shall be provided with braided copper wire jumpers.

#### 9.58 **Miscellaneous:**

- i) List of Vendors for major items of Transformer (CRGO material, Winding conductor, CTC conductor, Pre-compressed press board, Air Cell, Gaskets, OTI & WTI with repeater, RTD, ROTI & RWTI, MOG, Buchholz relay & Oil surge relay, PRD, Motors for Fan & Pump, Pump, Unimpregnated densified laminated wood MCB, Fuse, Annunciator, Condition controlled Regenerative maintenance free Silica Gel breather, Radiators, LT Cables, Tank Manufacturer etc.) shall be submitted for Purchaser's approval after placement of order.

The above items shall be of reputed make.



- ii) Complete set of Gasket required for complete erection of the transformers shall be

9.59 **Mandatory Spares**

Mandatory spares as listed in Schedule – II/A shall be supplied along with the transformer as per ordered quantity. Prices of spares shall be firm and unit prices shall be quoted item wise in the price schedule.

9.60 **Special Tools and Tackles**

Tenderers shall furnish a list of recommended special tools and tackles, if required for installation and maintenance of each of the specified transformers.

One set (consisting of 4 Nos.) of hydraulic jack each having suitable capacity for the specified transformer shall be supplied if indicated in the 'Schedule-II/A'. The tenderer shall quote 'Firm' prices for the above items.

## 10.0 PARALLEL OPERATION

The transformers to be procured shall be compatible for successful parallel operation with the existing transformers. The design parameters / drawing / document of existing transformers of the existing Sub-stations (where these new transformers would be installed) would be provided to the successful bidder for above purpose. Design of the new transformer shall be done accordingly (Refer Design Criteria - Annexure 'D').

For parallel operation with other transformers (existing at respective sites), necessary provision is to be kept in transformer digital RTCC panel for tap changing operation in any of Master/Follower/Independent mode.

## 11.0 DESIGN CRITERIA

The basic design of the transformers shall be guided by the stipulations of 'Annexure-D' forming part of this specification.



## 12.0 DETAILED DESIGN REQUIREMENT

### 12.01 TANK

The tank shall be made of MS plate; so shaped as to reduce welding to a minimum. All seams shall be **double welded** for absolute oil – tightness [i.e. with a continuous cord on both sides of the plate (inside and outside of the tank), bottom & cover of the tank, turrets, flanges, etc.]. The Tank walls shall be reinforced by stiffeners of structural steel for general rigidity and also to damp transformer noise. All welding shall be done electrically and relieved of welding stresses. Welding conforming to IS 9595. After completion of tank and before painting, **dye penetration test** (non-destructive) shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing parts and test reports shall be submitted to the Purchaser.

The tank of all transformers shall be complete with all accessories and shall be designed so as to allow the complete transformer in the tank & filled with oil, to be lifted by crane or jacks, transported by road, rail without over straining any joints and without causing subsequent leakage of oil.

The main tank body (during fabrication stage) excluding tap changing compartments, radiators and coolers shall be capable of withstanding full vacuum specified under respective clause of Testing.

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

The base channels and tank stiffeners shall be so designed to prevent retention of water. Wherever possible the transformer tank and its accessories shall be designed without pockets wherein gas might be collected otherwise. Where pockets cannot be avoided pipes shall be provided to vent the gas into the main expansion pipe. The vent pipes shall have a minimum inside diameter of 15mm except for short branch pipes, which may be 6mm minimum inside diameter. All joints shall be welded.

Each tank shall be provided with lifting lugs for lifting transformer with oil, minimum four jacking lugs and suitable haulage holes.

Each tank cover shall be of adequate strength and shall not distort when lifted.



Inspection opening of adequate size and in numbers as required shall be provided as necessary to give easy access to bushings or changing ratio or testing earth connection. Tank cover and inspection covers shall be provided with suitable lifting arrangement unless otherwise approved. Inspection covers shall not be more than 25 Kg each.

Protection shall be provided, where necessary, for each capillary tube required for oil and winding temperature indicators. The thermometer pocket shall be fitted with captive screwed caps to prevent the ingress of water. Pockets shall be located in the position of maximum oil temperature at C.M.R. & it shall be possible to remove the instrument bulbs without lowering the oil in the tank.

Gas venting - The transformer cover and generally the internal spaces of the transformer and all pipe connections shall be designed to provide efficient venting of any gas in any part of the transformer to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer is being mounted.

Gasket for tank & cover - All gasket joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasket joints shall preferably of O-ring and groove type. All tank gaskets/O-rings used shall be of NBR (Acrylonitrile butadiene Rubber) conforming to IS 4253. Material selected shall suit temperature conditions expected to be encountered at the site. All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket/O-rings is compressible, metallic stops/other suitable means shall be provided to prevent over-compression. The properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149 read with latest amendments. Gaskets and O-rings shall be replaced every time whenever the joints are opened.

The tank shall be subjected to leakage test at fabrication stage (oil tightness test) as specified under respective clause of Testing. After the test all the welded joints will be



checked for leakages. No valve shall drip and no gasket joints shall sweat.

The transformers are to be provided with bi-directional flanged wheels and axles shall be of such dimensions and so supported that under any service conditions they shall deflect sufficiently to interfere with the movement of the transformer. Suitable locking arrangements shall be provided to prevent accidental movement of the transformer. All wheels shall be detachable and shall be made of steel as required. The wheels shall be suitable for 1676mm rail gauge on minor axis & 2286 mm on major axis and provision for fixing the wheels suitable for 2500 mm & 3048mm rail gauge on major axis shall also be kept as per 'Annexure-D', however exact measurements shall be finalized during detailed engineering. The wheels shall be so arranged that they can be turned through an angle of 90° when the tank is jacked up clear of the rails. Means shall be provided for locking the swivel movement in positions. The wheels shall also be so placed that pinch bar can be used to move the transformer. To prevent movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

Main tank conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge. The conservator shall be liberally dimensioned such that at the lowest ambient temperature and no load on the transformer the oil level shall not recede too low and at the highest ambient temperature & full load on the transformer the oil, shall not spill into the breather pipe or to the exterior. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate self-life, life expectancy in operation and the recommended replacement intervals.

Each conservator vessel shall be fitted with adequate Condition controlled Regenerative maintenance free Silica Gel breather (each 100% capacity) as earlier stated, with connecting piping and isolating valves so that one breather can be removed keeping other in service even when the transformer is in energized condition. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other



structure supplied by the manufacturer, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such that:

- a. Passage of air is through silica gel and shall be such designed so that colour of silica gel crystals can be seen from distance due to moisture absorption.
- b. Silica gel is isolated from atmosphere by an oil seal.
- c. Breather is mounted approximately 1.4 meter above ground level.
- d. To minimize the ingress of moisture, Manufacturer shall provide flexible connection pipes to be used during replacement of any silica gel breather.

All the valves opening directly to the atmosphere shall be fitted with blanking flanges. Means shall be provided for padlocking all bottom valves in the open and closed positions. This is required for the valves where opening device like hand wheel, keys etc. are the integral part. Each valve shall be provided with indicator to show the actual position of the valve. The drilling of valve flanges shall comply with requirements of IS 3639.

Facilities shall be provided for mounting the current transformers externally on the neutral bushings adjacent to the tank. The CTs shall be complete with proper weatherproof casing kiosk by the Transformer manufacturer. The requisite numbers and type of terminals for the above purpose both at the C.T. and the marshalling kiosk shall be intimated to the successful bidder during detail Engineering.

Two (2) earthing terminals suitable for connection to 50 x 6 mm / 75 x 12 mm galvanized steel grounding flat capable of carrying for 2 seconds the maximum short circuit current of the system to which the transformer is connected shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

Two earthing terminals suitable for connection to 50 x 6 mm / 75 x 12 mm galvanized steel grounding flat shall also be provided on each cooler, individual/common marshalling box and any other equipment mounted separately (exact size to be finalized during detailed engineering). For the tank-mounted equipment like online drying/ Online DGA/ Optical Sensor Box etc. as applicable, double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper link.





Equipotential flexible copper links of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover shall be provided. For other components like - pipes, conservator support etc. connected to tank shall also be provided with equipotential flexible copper link.

Each transformer unit should have provision for earthing and connected to grounding mat when not in service. For this purpose, neutral shall have provision for connection to ground by a brass/tinned copper grounding bar supported from the tank by using porcelain insulators. The end of the tinned/brass copper bar shall be brought to the bottom of the tank at a convenient point for making bolted connection to 75 x 12 mm or 50 x 6mm galvanized flats connected to station grounding mat. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper. Respective terminals shall also be earthed through neutral by flexible copper connection. Manufacturer shall provide suitable arrangement for the above.

#### 12.02 BUCHHOLZ RELAY

Double float, reed type Buchholz relay shall be provided in series of the connecting pipe between the oil conservator and the transformer tank with minimum distance of five times pipe diameters between them. Any gas evolved in the transformer shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located suitably at about 1200 mm above ground level to facilitate sampling while the transformer in service. Suitable canopy shall be provided to prevent ingress of rainwater. It shall be provided with two potential free contacts (Plug & socket type arrangement), one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

The Buchholz relay shall not operate during starting/ stopping of the transformer oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the transformer during the external fault conditions. Pressurized water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.



### 12.03 COOLING PLANT

The conservator shall be liberally dimensioned such that at the lowest ambient temperature and no load on the transformer the oil level shall not recede too low and at the highest ambient temperature & full load on the transformer the oil, shall not spill into the breather pipe or to the exterior.

Main conservator shall have air cell type constant oil pressure system and shall be fitted with magnetic oil level gauge with low oil level potential free contacts. OLTC shall have conventional type conservator with prismatic oil level gauge. Conservator tank shall have adequate capacity with highest and lowest visible levels to meet the requirements of expansion of total cold oil volume in the transformer.

Conservator shall be positioned so as not to obstruct any electrical connection to transformer. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

There shall not be any pocket formation in radiators and coolers in which moisture may collect. Clearance between all pipe work and live parts shall be more than the clearances specified for live parts to earth in relevant standards.

Radiators' top and bottom headers shall be connected to the tank through isolating valves. Each in of a radiator bank shall have top and bottom gate valves. Each radiator shall be provided with drain plug at the bottom and air release plug at the top.

The oil circuit of all cooler shall also be provided with the following: - Removable blanking plates to permit the blanking off the main oil connection of each cooler.

A thermometer pocket fitted with a captive screwed cap on the inlet and outlet oil branches of each separately mounted cooler bank.

All oil piping shall be with flanged gasket joints. The drilling of oil pipe flanges shall comply with relevant IS. Separate expansion piece (expansion joint) shall be provided in each oil pipe connection between the transformer and the separately mounted oil cooler to avoid transformer Vibration being transmitted to the cooler Banks.

Drain valves/plugs shall be provided in order that each section of pipe work can be



drained independently.

- Minimum thickness
- a. Conservator plate: 5.0 mm
  - b. Radiator fins: 1.2 mm

Each radiator bank shall be provided with the following minimum accessories:

- a. Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
- b. Top and bottom shut off valves
- c. Drain Valves and sampling valves
- d. Top and bottom oil filling valves
- e. Air release plug
- f. Two grounding terminals for termination of two (2) Nos. suitable galvanised steel /GI flats.
- g. Thermometer pockets with captive screw caps at cooler inlet and outlet.
- h. Lifting lugs

#### 12.04 AIR BLOWERS (FANS) & PUMPS

Air blower fans for air blast cooling shall be motor driven. They shall be suitable for continuous operation. Air blowers shall be complete with air ducting and coolers shall be designed so that they operate with a minimum of noise. In order to reduce transmission of noise and vibration the blowers shall be either mounted independently or alternatively, on approved form on anti-vibration mounting shall be adopted. It shall be possible to remove the blower fan complete with motor without disturbing or dismantling the cooler structure. Blades of blowers/fans shall be suitably painted for outdoor use. If blowers / fans are mounted at a height less than 2.5 meter suitable painted wire-mesh guards shall be provided to prevent accidental contact with blades, for blowers / fans mounted at more than 2.5 M height shall be provided with outside guards against birds etc.

Full – duty oil pumps & motors shall be provided. Cooling fan motor & pump motor shall conform to IS 325 and its enclosures shall be equivalent to IP 55 or better degree of protection.

All necessary expansion joints, valves, bends, fittings & oil piping shall be



supplied.

- One number standby fan shall be provided with each radiator bank.
- Two (2) nos., 100% centrifugal or axial in line oil pumps, as applicable, (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be taken to prevent mal-operation of Buchholz relay when all oil pumps are simultaneously put into service.
- An oil flow indicator shall be provided for the confirmation of the oil flow direction. An indication in the flow indicator and potential free contacts for remote alarm shall be provided.
- Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.
- Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS 325 / IEC 60034. Each cooling fan and oil pump motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type or better. Motors shall have hose proof enclosure equivalent to IP 55 or better.
- The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanized or corrosion resistant paint should be applied to external surface of it.
- Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.
- Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The manufacturer shall recommend the setting of WTI for automatic changeover of cooler control over entire cooling option (from ONAN to ONAF to OFAF etc.). The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.
- Suitable manual control facility for cooler fans and oil pumps shall be provided. Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans and pump manually.
- The changeover to standby oil pump in case of failure of service oil pump shall be automatic.



- Following lamp indications shall be provided in cooler control cabinet:
  - Cooler Supply failure (main)
  - Cooler supply changeover
  - Cooler Supply failure (standby)
  - Control Supply failure
  - Cooling fan failure for each bank
  - Cooling pump failure for each pump
  - Common thermal overload trip
- One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet.
- The Cooler Control Cabinet / Individual Marshalling Box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired up to the terminal board in the Cooler Control Cabinet/ Marshalling Box. All the CT secondary terminals in the Cooler Control Cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.
- All the necessary terminations for remote connection to Purchaser's panel shall be wired up to the Marshalling Box.
- In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided.
- Weather-proof Cooler control cabinets complete with 2.5mm<sup>2</sup> Copper Conductor of 1.1KV grade PVC/XLPE wirings, cable glands, heaters and cubicle light AC power outlet socket shall be supplied with the following:
  - i. Local control selector switches Auto / OFF / Manual.
  - ii. MCB with motor protection for supply source 1 and 2.
  - iii. No volt contactors for supply failure.
  - iv. Winding temperature Indicator for both HV & LV.
  - v. Control contacts (two sets) on WTI – one for Automatic fan starting and other for automatic pump starting.
  - vi. Alarm and at least 2 sets of Trip Contacts on WTI.



- vii. Oil Temperature Indicator.
- viii. Alarm and 2 sets of Trip contacts on OTI.
- ix. Thermal overload relays with Contractors of Fan and Pump Motor Starters.
- x. Contactors for Auto-supply change over from supply source 1 to 2 or vice versa as in (ii) above.
- xi. Necessary Interlocking Contactors.
- xii. Heaters and Heater Switch.
- xiii. Illumination lamp & lamp switch.
- xiv. Auxiliary contactors for starting and stopping the pumps and fans from Remote Control Panel.
- xv. Alarm and trip contacts on Buchholz.
- xvi. Alarm contacts on low oil level alarm.
- xvii. Trip contact on Tap Changer Buchholz.
- xviii. Alarm contact on oil flow indicator.
- xix. Fan and pump motors.
- xx. Signal lamps for Fans & Pumps 'ON' Local indication.

The items between (xv) to (xix) above may be on Transformer itself. The followings are to be supplied along with Remote Control panel complete in all respects.

- xxi. Signal lamp for control supply "ON".
- xxii. Remote Control selector switches Auto / OFF, Hand / OFF.
- xxiii. Signal lamp for Fans and Pumps; "ON" Indication.
- xxiv. Start and Stop push buttons for each cooler Bank.
- xxv. Winding Temperature Indicator for both HV & IV.
- xxvi. Alarm circuits for (a) pump and fan failure (b) 415V/240V/110V AC supply failure.
- xxvii. Test circuit for fan and pump motors even when the transformer is in de-energized condition.

The automatic cutting in and cutting out of radiator cooling fans and pumps shall be with the variation of transformer load or temperature.



## 12.05 CORE

Core materials shall be directly procured either from manufacturers or through authorized importing organization of repute. Indian transformer manufacturers shall use core material as per above specification with BIS certification.

The core shall be constructed from non-ageing, Cold Rolled Grain Oriented (CRGO) silicon steel laminations of low loss grade and high permeability grade. The thickness of sheet steel should be 0.27mm preferably.

The core limbs shall be bound by resin bonded glass tapes. The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2.5 KV (rms) for 1 minute in air.

The core lamination joints will be 45° mitred / interleaved which avoids local heats and reduces core loss.

After building in the horizontal position the core is to be erected using a core setting device in order to avoid bending of core and resultant mechanical stresses.

The core clamping frame shall be provided with lifting eyes. The whole core shall be electrically connected by an iron/copper strip at the tank for being earthed.

The core shall be earthed to the core clamping structure at one point only, through a removable external link suitably located and protected to facilitate testing after installation of the transformer.

Conventional core construction/clamping drives a hole through core laminations. This weakens the core. As such a method of construction/clamping should be adopted so that hole through core laminating is avoided. Suitable tie plates and clamps to be incorporated so that core holes and core bolts are eliminated as far as practicable.

The size of the core shall be such that it will be able to withstand continuously 15% over voltage/over fluxing. The core-clamping frame shall be provided with lifting eyes for the purpose of tanking and de-tanking the active parts of the transformer. The whole core shall be electrically connected by an iron/copper strip to the tank for being earthed to drain off any electro static potentials that may build up.



A drawing furnishing the details of the internal earthing design shall be submitted during detail engineering.

No load loss measurement by dummy coil along with checking of physical dimensions & flux density calculation may be carried out during stage inspection of core as per discretion of the Purchaser.

Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

#### 12.06 COIL

The manufacturer shall ensure that windings of all transformers are made in dust proof (Cleanroom class ISO 9 or better as per ISO 14644-1) humidity controlled environment with positive atmospheric pressure, preferably air conditioned atmosphere.

The conductors shall be of electrolytic grade copper free from scales and burrs. Oxygen content shall be as per IS 12444.

Each coil should be of paper insulated continuous and smooth electrolytic copper conductor having minimum 99.90% purity.

The high voltage winding should be provided with a surge shield winding in order to distribute impulse voltage uniformly along with winding. The surge shield will be such that it will increase the series capacitance thereby giving a uniform surge voltage distribution.

The coils should be pre-shrunk before assembly. All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly.

Adjustable push bolts at the top end should clamp the coils. The coils and insulation will be perfectly dried and then oil impregnated at a high degree of vacuum followed by a keeping period at the high vacuum in order to drive out all traces of air.

Value of the insulation resistance of the winding measured immediately after impregnation shall be intimated to the Purchaser.

The whole assembly shall be finally held by suitable means under axial compression of at least twice the aerial thrust likely to be set up under a terminal short circuit.





The switching & Lightning surge withstand strength of the windings shall be developed according to the best modern practice. Inter phase insulation barriers shall be provided. The winding assembly with all connections, spacers, clamps and leads shall be electrically and mechanically strong to withstand the stresses arising out of 2 sec. dead short circuit at the terminals. No loosening or insulation weakness should result.

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

The windings shall be designed to withstand the relevant dielectric tests. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and considering the fact that the system will not always be in the new factory condition.

All insulating materials and structures shall be protected from contamination and the effects of humidity during and after fabrication, and after receipt, by storing them in a separate, climate-controlled area.

Winding paper moisture shall be less than 0.5%.

Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

Either brazing /crimping type of connections shall be permitted for joints. It shall be time proven and safely withstand the cumulative effect of stress which may occur during handling, transportation, installation and service including due to line to line and line to ground Short circuits. Manufacturer shall have system which allows only qualified personnel to make brazing or crimping joints.

The whole assembly shall be finally held by suitable means under axial compression of at least twice the aerial thrust likely to be set up under a terminal short circuit.

The switching & Lightning surge withstand strength of the windings shall be developed according to the best modern practice. Inter phase insulation barriers shall be provided. The winding assembly with all connections, spacers, clamps and leads shall be electrically and mechanically strong to withstand the stresses arising out of 2 sec. dead short circuit at the terminals. No loosening or insulation weakness should result.



Stage inspection of winding: Physical & dimensional check, purity check of copper material of conductor used in the coils, measurement of resistance.

TC for current density check to be submitted separately. However, all inspection related issues to be carried out as per directives of QC&I dept. of Purchaser.

#### 12.07 TERMINAL ARRANGEMENT

Terminal arrangement of the transformer for HV, IV and LV shall be as per IS-2099-1973 (latest revision) if any. The bushing terminals and terminal fittings shall carry the full rated transformer current continuously without the temperature rise of any part exceeding permissible limit over a maximum ambient air temperature of 50°C. They shall operate satisfactorily in heavy rain or in industrial atmosphere laden with abrasive coal dust, ash, fog, gas, salt and mild acids. They shall be free from corona, and shall not cause radio interference. The detail requirement of Bushings has been mentioned under Annexure 'D'.

#### 12.08 LOADING GUIDE

The transformers shall be capable of being overloaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

### 13.0 INSULATING OIL

The insulating oil shall be virgin high grade Inhibited, conforming to IEC-60296 & respective parameters specified at Annexure – E, while tested at supplier's premises. The same quality of Oil shall be used for Main Transformer and OLTC also. The transformer supplier shall furnish test certificates from the supplier against the acceptance norms as mentioned at Annexure – E, prior to dispatch of oil from refinery to site.

Under no circumstances, poor quality oil shall be supplied for the transformer and the unused Inhibited Insulating Oil parameters, including parameters of oil used at



manufacturer's works, processed oil, oil after filtration and settling shall be as per Annexure – E. The oil test results shall form part of equipment test report.

Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.

Inhibited oil used for first filling, testing and impregnation of active parts at manufacturer's works, if any, shall be of same type of oil (in line with IEC 60076-3) which shall be supplied at site and shall meet parameters as per specification.

Particles in the oil: The particle analysis shall be carried out in oil sample taken after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17 - "Effect of particles on transformer dielectric strength".

Transportation of Oil: The oil required for first filling of the transformer plus ten percent (10%) extra oil should be supplied along with the transformers. The oil drums which will become the property of the purchaser shall be made of steel sheet suitable to withstand the rigorous transit hazards without leakage. The transformer oil shall be new (unused) and delivered in sealed (tamper-proof), non-returnable, epoxy coated from inside, perfectly clean steel barrels of 209 - 210 litres nominal capacity.

The characteristic of oil shall be as per requirement specified in Annexure – 'E' forming part of this specification. Transformer manufacturer shall submit offer for inspection of transformer oil during final acceptance test of Transformer and submit necessary factory acceptance test reports of the same to the Purchaser for issuance of dispatch instruction.

## 14.0 TAP & TAP CHANGER GEAR

On-load tap changing gear (OLTC) shall be supplied as specified in the Annexure-D. OLTC shall be type tested for temperature rise of contact, short circuit current test, dielectric test etc. as per IS: 8468 / IEC: 60214 and IP 55 test on Driving Mechanism Box. Type test report shall be submitted to the Purchaser during drawing approval stage for acceptance.



The OLTC switch contacts shall be located in a separate oil filled chamber complete with its own oil preservation system (conservator), Oil surge relay, shut-off valves, prismatic oil level gauge, MOG with contacts, gas vents etc.

The details of the method of diversion of the load current during tap changing, mechanical construction of the gear and the control features of the OLTC gear shall be enclosed with the tender. Information regarding the service experience on the gear and a list of important users shall also be furnished. The current diverting contacts shall be housed in separate oil chambers, not communicating with the main tank of the transformer. The contacts shall be accessible for inspection and their tips shall be replaceable. The transformer shall give full load outputs on all taps.

Local OLTC Control Cabinet shall be protection class of IP 55 or better, for outdoor installation. OLTC local cabinet shall be of 2.5mm (Min.) thick sheet steel (CRCA). Front door may be glass with steel frame as per approved drawing. All access doors shall be provided with channel rubber / neoprene gasket all around.

Local OLTC Control Cabinet shall have following control –

#### 14.01 MANUAL MECHANICAL CONTROL

The cranking device for operation of the OLTC gear shall be removable and suitable for operation at about 1350mm above ground level. The mechanism shall be complete with following: -

- i) A mechanical tap position indicator.
- ii) A mechanical operation counter.
- iii) Mechanical stops to prevent over cranking of the mechanism beyond extreme tap positions.
- iv) The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of ancillary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safe guard the transformer and its ancillary equipment.
- v) The equipment shall be suitable for supervisory control and indication with make



before break multi-way switch, having one potential free contact for each tap position. This switch shall be provided in addition to any other switch/switches, which may be required for remote tap position indicator.

#### 14.02 ELECTRICAL CONTROL

This shall include local and remote electrical control. The control circuit shall have the following features:

- i) An interlock to cut off electrical control automatically upon recourse being taken into the manual mechanical control.
  - ii) Reinforcement of the initiating impulse for a tap changes, ensuring completion of the initiated tap change to the next (higher or lower) tap.
  - iii) "Step-by-step" operation, ensuring only one tap change from each tap changing impulse and a lockout of the mechanism if the control switch (or push button) remains in the operated position.
  - iv) An interlock to cut out electrical control when it tends to operate the gear beyond either of the extreme tap positions.
  - v) An electrical interlock to cut-off a counter for a reverse tap change being initiated during a progressive tap change and until the mechanism comes to rest and resets circuits for a fresh operation.
  - vi) The following auxiliary devices for electrical control of the OLTC shall be housed in weatherproof cabinet complete with 2.5mm<sup>2</sup> copper conductors, of 1.1 KV grade, fire retardant low smoke (FRLS) type PVC/XLPE wirings near the transformer and also on the tap changer drive.
- a. Motor protective switch with magnetic and thermal overload devices for controlling the incoming A.C. supply.
  - b. Control Selector Switch Local / Remote. 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (i.e. from CMB, digital RTCC, SCADA, SAS etc.) shall be cutoff/ blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from Driving Mechanism (DM) Box. In remote mode electrical



commands from CMB/ digital RTCC/SCADA/SAS etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

- c. Tap changer-driving motor.
- d. Limit switch to open in position 1 and highest position.
- e. Hand interlock switch.
- f. Local control / push button Raise / Lower mechanically operated contact closed during "Raise TC operation.
- g. Mechanically operated contact closed during "Lower" TC operation.
- h. Mechanically operated contact open during tap change.
- i. Mechanically operated contact closed during tap change.
- j. Motor contact radial switch for Tap position Indicator.
- k. Odd / Even paralleling switch.
- l. Tap change motor contactor Raise tap position No.
- m. Tap change motor contactor lower tap position No.
- n. Brake contactor for Motor.
- o. Step by step contactor.
- p. Position Indicator resistance/thermostat.
- q. Heaters in T.C. driving gear.
- r. Signal lamp for "Motor protective Switch Off".
- s. Emergency push button - "Off for Motor protective Switch".
- t. Contact for passage position.

vii) The following indicative list of devices shall be mounted on Remote Tap Changer Control panel complete with 2.5 mm<sup>2</sup> copper conductor of 1.1 KV grade PVC/XLPE wirings to be offered by Tenderer:

- a. Out of step relay.
- b. Time delay for out of step relay.
- c. Sequence selector switch Independent / off / Follower / Master.
- d. Remote control switches Raise / Lower / Neutral.
- e. Auxiliary Raise Contactor.
- f. Auxiliary Lower Contactor.



- g. Auxiliary step-by-step contactor.
- h. Electric bell for out of step alarm.
- i. Buzzer for tap change in progress.
- j. Signal lamp for tap change in progress.
- k. Signal lamp for out of step.
- l. Signal lamp for tap change control supply "ON".
- m. Tap position Indicator.
- n. Push button switch.

Necessary interlock, blocking independent control when the units are in parallel group control (parallel operation) through Master/Follower /Independent, shall be provided with proven scheme. Under abnormal condition if one tap changer sticks, out-of-step condition shall have to be limited to one tap difference between the units by switching off supply to motor. Details of out-of-step protection provided for the taps shall be furnished in the tender.

Cables for control interconnection between the OLTC control cabinet and digital RTCC control panels is under purchaser scope. Cable glands shall however be fitted in the control cabinet as per Purchaser's requirement.

Any online monitoring equipment i.e. Optical Temperature Sensors & Measuring Unit, Online DGA and Moisture Analyzer etc. if provided, for individual transformer unit including spares (if any), shall be IEC 61850 compliant (either directly or through a Gateway) for successful integration with Purchaser's SAS/ SCADA system. In this regard, necessary Ethernet switches, power & control cables including optical cable, patch chord, etc. as may be required upto MB, all the cables from digital RTCC to DM and any special cable between MB to switchyard panel room/control room shall be provided by the manufacturer. These equipment shall be suitable for operation at ambient temperature of 50 Deg C.

However, power cable, control cables, as applicable, between MB to switchyard control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall not be considered included in scope.



## 15.0 COOLING EQUIPMENT FOR TRANSFORMER

The transformer with cooling system of ONAN/ONAF/OFAF shall be quoted. The full duty oil pumps and motors shall be provided. The necessary expansion joints, valves, bends, fittings and oil piping shall be supplied.

Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The contractor shall recommend the setting of WTI for automatic changeover of cooler control from ONAN to ONAF to OFAF etc. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

Fan motor controls will be actuated automatically from winding temperature indicator contacts. Provision shall however be kept for manual operation from local cooler control panel and remote control panel. Necessary auxiliary contacts i.e. NO & NC contacts shall be provided for remote annunciation and SCADA connectivity for cooling fans & pumps, OTI, WTI, Buchholz relay, Surge Relay, PRV, MOG etc. as applicable. 4-20 mA output signal with adequate spare output signal to be provided for OTI & WTI for remote display and SCADA connectivity.

Weather-proof Cooler control cabinets complete with 2.5mm<sup>2</sup> Copper Conductor of 1.1KV grade PVC/XLPE wirings, cable glands, heaters and cubicle light AC power outlet socket shall be supplied with accessories already mentioned categorically under relevant section of cl.10.3.

The automatic cutting in and cutting out of radiator cooling fans and pumps shall be with the variation of transformer load or temperature.

## 16.0 HAND TOOLS

One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm or as compatible, one set each), adjustable wrenches (8 & 12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable





hacksaw (one), and cold chisel (one), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied for at least one substation to cater to number of transformers.

## 17.0 CONTROL CONNECTIONS AND INSTRUMENT WIRING, TERMINAL BOARD AND FUSES

All wiring connections, terminal Boards, fuses and links shall be suitable for tropical atmosphere. All terminals of the local instruments, devices, CT, fans, etc. shall be also of weatherproof construction. Any wiring liable to be in contact with oil shall have oil resisting insulation and bare ends of standard wire shall be sweated, together to prevent seepage of oil along with wire.

Panel connections shall be neatly and squarely fixed to the panel. All instruments and panel wiring shall be run in PVC or non-rusting metal cleats of the limited compression type. All wiring to a panel shall be taken from suitable terminal boards.

Where conduits are used, the runs shall be laid with suitable falls, and the lowest parts of the run shall be external to the boxes. All conduit runs shall be adequately drained and ventilated conduits shall not run at or below the ground level.

When 415V connections are taken through junction boxes or marshalling boxes they shall be adequately screened and 415 'VOLTS DANGER' notice must be affixed outside of the junction boxes or marshalling boxes.

All wiring shall be in accordance with relevant IS. All wiring shall be stranded copper of 1.1 KV grade, FRLS type and approved make of size not less than 4 Sq. mm. for CT leads and not less than 2.5 mm<sup>2</sup> for other connection. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.

Multi-way terminal block complete with mounting channel, binding screws and washers for wire connections and marking strip for circuit identification shall be provided for terminating the panel wiring. Terminals shall be stud type, suitable for terminating 2nos. 2.5mm<sup>2</sup> stranded copper conductor and provided with acrylic insulating cover. Terminal for CT secondary leads shall have provision for shorting and grounding.

All wires shall have ferrules, which bear the same number at both ends. Same ferrule



numbers shall not be used on wires in different circuits on the same panels.

Ferrules shall be white insulating material and shall be provided with glossy finish to prevent the adhesion of dirt. They shall be clearly and durably marked in block and shall not be affected by damper oil.

Stranded wires shall be terminated with tinned Ross terminals, Claw washer or crimped tubular lugs. Separate washers shall be used for each wire. The size of the washers shall be suited to the size of the wire terminated. Wires shall not be joined or tied between terminal points.

No live metal shall be exposed at the back of the terminal boards. All fuses shall be of cartridge type (HRC) or better. Fuses and links shall be labelled.

## 18.0 INTERNAL EARTHING ARRANGEMENT

All metal parts of the transformer with the exception of the individual core laminations, core bolts and associated individual clamping plates shall be maintained at same fixed potential.

The top main core clamping structure shall be connected to the tank body by a copper strip. One of the followings shall earth the bottom clamping structure: -

- By connection through vertical tie-rods to the top structure.
- By direct metal-to-metal contact with the tank base maintained by the weight of the core and windings.
- By a connection to the top structure on the same side of the core as the main earth connection to the tank.

The magnetic circuit shall be earthed to the clamping structure at one point only through a link placed in an accessible position beneath the inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection.

Magnetic circuits having an insulated sectional construction shall be provided with separate earth links for each individual section.

Where coil-clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of transformer as the main earth



connections.

All earthing connections with the exception of those from the individual coil clamping rings shall have adequate bigger cross sectional area. Connections inserted between laminations of different section of cores shall have a cross sectional area of not less than 0.2 Sq.cm.

## 19.0 PAINTING

All steel surfaces exposed to weather shall be given a priming coat of zinc chromate and two coats of light grey paint.

All steel surfaces in contact with insulating oil, as far as practicable, shall be painted with heat-resistant, oil-insoluble insulating varnish.

The surface to be painted shall be hot sandblasted to remove all rust and mill scale of foreign adhering matter or grease.

All paints shall be carefully selected to withstand tropical heat and extremes of weather as indicated in the specification. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C.

The typical painting details for transformer, misc. panels, etc. shall be as per 'Anx.-D'.

The detailed painting procedure shall be finalized during award of the contract.

## 20.0 DRYING OUT BEFORE DESPATCH

Each Transformer shall be sealed under a positive pressure of dry N<sub>2</sub> gas for delivery (with cylinder, pressure gauge etc.). As it may be necessary to dry out the unit at site, the contractor shall furnish detailed instructions regarding the drying out at site. Measurement of dew point of dry air / Nitrogen at the time of filling and after 24 hours in the transformer tank shall be done. Dew point of dry air / Nitrogen at the time of transformer dispatch should be better



than (-)

30°C. Also, the dew point of dry air / nitrogen cylinders attached for make up during transportation should be of the order of (-) 50°C.

If the Transformer is transported with tank partly filled with oil (covering the winding) the necessary oil gauge shall be provided in the tank for supervision of the oil level, oil gauge shall have proper-chained cover cap.

## 21.0 MAXIMUM LOSSES

The maximum permissible losses (No load loss, load loss and auxiliary loss) at rated voltage/current (at 75 °C) have been specified in Annexure-D for the transformers covered under this specification. Following penalties shall be levied on the manufacturer/contractor (as the case may be) if losses measured during testing are found to be within +2% tolerance of the losses specified in Annexure-D, beyond which the transformer shall be liable for rejection. No benefit shall be given for supply of transformer with losses (measured during testing) less than the losses specified in Annexure-D.

Sl. No.	Differential of specified losses vs Measured losses	RATE (in INR per KW)
1	No load Loss	Rs. 10,00,000/KW
2	Load Losses	Rs. 8,00,000/KW
3	Auxiliary Losses	Rs. 8,00,000/KW

Note: For a fraction of a kW, the penalty shall be applied on pro rata basis.

## 22.0 TYPE TESTS

The following Type Tests shall be conducted by the manufacturer on one transformer of each type of voltage class & rating as per relevant stipulation in IS-2026 (latest version).

- Lightning impulse test: The lightning impulse level i.e. tests voltage values are stipulated in 'Annexure-D'.
- Temperature rise test: Temperature rise test shall be conducted at minimum tap. The test shall be conducted on transformer for different ratings, i.e., ONAN, ONAF, OFAF for different windings. The temperature rise shall be limited to stipulation indicated in 'Annexure-D'.



## 23.0 QUALITY ASSURANCE CHAPTER

Shall be as per NIT document.

## 24.0 CYBER SECURITY REQUIREMENT

Shall be as per NIT document.

## 25.0 DELIVERY SCHEDULE

Shall be as per NIT document.

## 26.0 TRANSPORTATION

The supplier shall obtain clearance of the competent authority regarding the limiting dimension permissible for transport by rail / road. The supplier shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment and the entire responsibility regarding transport clearance etc. shall rest on the supplier. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the supplier to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site. In the event of an award of contract three (03) copies of the drawing showing the maximum loading dimensions of large single piece / items of the equipment inset with the clearance sections shall be submitted.

The supplier shall dispatch the transformer filled with pure dry inert  $N_2$  gas at positive pressure depending upon the transport weight limitations.

A graph showing pressure vs. temperature shall be attached for reading pressures at different temperatures. Necessary valves, two-stage pressure regulators, filled up Nitrogen cylinders etc. along with other accessories required shall be provided with the tank for intermittent replenishment, if required during transportation.

Transformer shall also be fitted with at least two (02) nos. Electronic Impact Recorder (on returnable basis) with vehicle tracking system during transportation to measure the magnitude and duration of the impact in all three directions (axial, lateral and longitudinal).

The acceptance criteria and limits of impact in all three directions shall not generally exceed "3g" for 50 mili sec (20Hz) during transportation. Acceptance criteria and limit of impacts shall be



submitted by the manufacturer during detail engineering stage and final acceptance shall however be as per detailed scrutiny /analysis of time stamped recorder data for respective type of transformer.

The recording shall commence in the factory before dispatch and must continue till the unit is delivered at site. The data of electronic impact recorders shall be downloaded at site by the manufacturer with their own arrangement and a soft copy with print out of it shall be handed over to the Site Engineer In-Charge during unloading of transformer. The impact recorder shall be taken back by the manufacturer with their own arrangement to the manufacturer's works for their analysis. The manufacturer shall submit the analysis report of impact recorder back to the Purchaser for their record within three weeks of delivery of transformer along with a line of confirmation regarding the shock withstood during transportation.

In case the impact recorder indicates some serious shock during shipment, the equipment shall thoroughly be internally inspected by the manufacturer's representative free of cost immediately at site to ensure complete healthiness of the equipment. A line of confirmation towards complete healthiness of the equipment shall be required from the manufacturer.

The supplier shall mount Vehicle Tracking System (GPRS / GPS / GSM based) to track the exact position of the vehicle on which the transformer is being loaded for transportation.

During detail engineering stage approval of the equipment (Impact recorder & Vehicle tracking system) shall be taken.

## 27.0 DRAWINGS / DOCUMENTATION

### a. Languages

All drawings, technical data or correspondence, submitted to the Purchaser for approval or for information, shall be in English. All dimensions shall be in Metric Units.

### b. Tender Drawings

The tenderer shall submit a tentative OGA drawing with the bid documents.

### c. Details of Auxiliary

Within forty five (45) days from the date of receipt of the Purchaser's Letter of Intent the



Contractor shall provide the Purchaser with details of all the auxiliaries to be supplied, and also of others, not forming part of the Contractor's supply but essential for the safe and satisfactory working of the plant and equipment in terms of the contract.

**d. Procedure for Drawing Approval**

Three (3) prints with dark lines on white background shall be furnished of each drawing submitted for approval along with soft copy. One copy shall be returned to the contractor marked "Approved" and if they are not in conformity with provision of the contract then this copy shall be marked "Approved Subject to Compliance of Comments" or "Resubmit after Compliance of Comments", the Engineer will give reasons for such correction and the Contractor shall make the necessary corrections and re-submit three (3) copies for final approval.

Immediately on receipt of a finally approved drawing the Contractor shall furnish the Purchaser with four (04) copies of prints of such drawing along with soft copy on CD medium and on e-mail.

Standard time for approval/commenting of drawings against each submission may be considered as 30 (thirty) days.

**e. Revision**

If any minor revision are made after a drawing has been approved, the Contractor shall furnish four (04) prints along with softcopy in the same manner as described above subsequent to each revision.

**f. Binding Data and Arrangement Plans**

Within thirty (30) days of the receipt of letter of intent the Contractor shall submit the following documents for approval of DVC:

- i) Dimensioned General layout and arrangement drawings of the equipment and its auxiliaries including part marking of all items with name of manufacturers as applicable with mounting arrangement of the cooling equipment (i.e. radiators, cooling fans & pump sets etc.) in either side of the transformer.
- ii) Outline drawings indicating weight, dimensions, forces and loads, to enable the design of the foundation structures and associated equipment to be completed by the Purchaser.



- iii) Structural drawings and schedule of all sleeves, foundation bolts and parts to be set in the foundation.
- iv) Schematic drawings of all piping, lubrication and cooling arrangement, wiring, connection and interlocking diagrams showing the points where connections have to be made by the Purchaser.
- v) Single line diagram of the oil flow system, Name Plate, Valve Schedule.
- vi) QAP including inspection test schedules of the transformer with all B/O items.
- vii) List of Vendors for major items of Transformer (CRGO material, Winding conductor, CTC conductor, Pre-compressed press board, Air Cell, Gaskets, OTI & WTI with repeater, RTD, ROTI & RWTI, MOG, Buchholz relay & Oil surge relay, PRD, Sudden pressure relay, Motors for Fan & Pump, Pump, MCB, Fuse, Annunciator, Condition controlled Regenerative maintenance free Silica Gel breather, Radiators, LT Cables, Tank Manufacturer etc.) shall be submitted for Purchaser's approval.
- viii) GTP for Transformer including Oil & Nitrogen injection based Fire prevention and Extinguishing System.
- ix) GTP for FOTS & online H<sub>2</sub> & moisture content monitoring system.
- x) **Along with above, Design data /calculation /document shall be furnished in respect of.**
  - A) Design Flux density
  - B) Weight of core, its dimensions & No load loss
  - C) Current density of Windings & its dimensions
  - D) Design pressure of Main Tank
  - E) Thermal stability to withstand rated short circuit current by verification of calculation.
  - F) Detailed Drawings

Soon after the arrangement plans and data have been approved detailed drawings clearly indicating overall dimensions, limiting dimensions for useful service and method of disassembly and assembly shall be furnished by the Contractor. Such drawings shall include the following:

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- i. Final Plans and layouts giving complete details against the above mentioned arrangement plans.
- ii. Assembly, sub-assembly and sectional drawing of every equipment.
- iii. Detailed wiring and connection diagram and arrangement of conduits for wiring various controls and instruments up to the required points.
- iv. Detailed piping layouts showing required interconnections.
- v. Detailed foundation plan drawings (showing center of gravity) with mounting arrangement of the cooling equipment (i.e. radiators, cooling fans & pump sets etc.).
- vi. An erection manpower estimate and detailed programme of shipment and erection.
- vii. General outline showing plan, elevation and end view dimensions. Side sketch for height of crane hook above ground required for lifting bushings and un-tanking the core, details of bushing top terminals, complete list of fittings and devices.
- viii. Name and Rating Plates: Full particulars vide IS-2026 (Part-I) – 1977.
- ix. Diagram plate: Electrical connections of the winding, numbering of taps, tapping switches, terminals, disposition of terminals, vector relationship, polarity and terminal marking of C.T. parts earthed through the tank and special details of any.
- x. Control circuit and wiring diagrams :
- xi. Circuit diagrams (Schematic) for cooler control & OLTC control, wiring diagrams of control cabinets, signalling and indicating devices, current transformers, block diagram showing interconnection control cables to be provided by the Purchaser, cable sizes and length to be supplied by the Contractor, table of recommended cable sizes for the Purchaser's interconnection cables, etc.
- xii. Drilling details and internal wiring of device supplied loose for mounting on the Purchaser's control board.
- xiii. Shipping outline: Outline profiles of plan, elevation and end view of transformer stripped for shipment, dimensions of projections referred to the physical centre lines, the position of centre of gravity and weight.
- xiv. Assembly of core and coils: Details of winding connections, insulation spacers, barriers, clearances, core insulation, compensating devices for shrinkage, etc., which will help the Purchaser to replace a set of windings in any future eventuality.



- xv. Bushing Assembly: Plan, elevation, out way view and details of joints and seals etc.
- xvi. Cooler Assembly: Out way view of arrangement and details of joints and important arrangements.
- xvii. Tap changing gear assembly.

#### **h. Assembly and Erection Instruction**

Within a reasonable time after purchase order but at least three months before delivery the Contractor shall furnish three sets of the following for the use of Purchasers field Engineers

- i. Descriptive literature and drawings (Erection key diagram / Part marking details) to illustrate the working principles, method of assembly and dismantling.
- ii. Instruction Book for proper erection and assembly of all equipment with programme of work and necessary instructions for checking and recording proper assembly of the plant.
- iii. Complete spare part handbooks with details of part nos., description and diagrams. Separate recommendations shall be made for the parts required for the first five (5) years of operation. Parts requiring frequent replacement shall be enlisted separately from parts required for ensuring reliability in unforeseen emergencies.

#### **i. Final Drawings and Operation Manuals**

The Contractor shall furnish six (06) complete set of prints and one permanent negative of all detailed drawings of the equipment including test certificates of all bought out items and Nitrogen injection based Fire prevention and Extinguishing System actually supplied along with soft copy for owner's future reference. Six (06) sets of comprehensive manuals for use in the operation and maintenance of the plant including Erection key diagram / Part marking details and soft copy of SFRA report (conducted at factory & site) shall also be furnished.

## **28.0 MISTAKES IN DRAWINGS**

The Contractor shall be responsible for and shall pay for any alterations of the work due to

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any discrepancies, errors or omission in the drawings or other particulars supplied by him whether such drawings or particulars have been approved by the Engineer or not, provided that such discrepancies, errors and omissions be not due to inaccurate information or particulars furnished to the Contractor by the purchaser's engineer but the Purchaser shall be responsible for drawings and information supplied by the Engineer and the Purchaser shall pay for any alterations of the work necessitated by reason of inaccurate Information supplied by the Engineer to the Contractor. If any dimensions figures upon a drawing or plan differ from these obtained by scaling the drawing or plan, the dimensions as figured upon the drawing or plan shall be taken as correct.

## 29.0 CO-ORDINATION WITH OTHER MANUFACTURERS

The Contractor shall co-ordinate with the Purchaser's other contractors/ manufacturers and truly exchanges all technical information to ensure satisfactory and economical design. No remuneration shall be payable by the Purchaser for such Technical co-ordinations.

The Contractor shall forward to the Purchaser copies of all correspondences and drawings, so exchanged.

The Tenderer shall co-ordinate in all respects with the manufacturer of Fire prevention and Extinguishing System by Nitrogen (N<sub>2</sub>) Injection method for Transformer etc. and shall freely exchange all relevant information to ensure satisfactory and economic design. The transformer manufacturer should ensure that the offered transformer will have all provisions required for successful installation and operation of the Fire prevention and Extinguishing System by Nitrogen (N<sub>2</sub>) Injection method along-with FOTS and online DGA & moisture content monitoring system , if supplied, and thus suitable measures shall be taken by the manufacturer, wherever required, so as to suit the above requirements. Charges for the same shall be included in the price of the transformer.

## 30.0 ANNEXURES

The following 'Annexure' are enclosed herewith this specification and shall form part of this

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specification

- Annexure A : General Site Information
- Annexure B : Auxiliary Supply system Data
- Annexure C : Inspection & Quality Control
- Annexure D : Design Criteria of Transformers
- Annexure E : Characteristics EHV grade Transformer oil
- Annexure F : Reference Standards for Transformers and connected equipment and device
- Annexure G : Vendor List

### 31.0 SCHEDULES

Tenderer must completely fill-in all the relevant schedules as mentioned below furnished along with this tender specification. Failure to comply with this requirement shall result in declaring the offer incomplete and accordingly rejection of the bids:

#### **Schedules: Part –I (Techno-Commercial Bid)**

Schedule : I/A – Schedule for Completion of Supply.

Schedule : I/B – Format of GTP to be submitted

Schedule : I/C – Schedule of Past Experience

#### **Schedules: Part – II (Price Bid)**

Schedule : II/A – Schedule of Items & Quantities (Prices to be quoted in the price format provided with NIT).

Schedule : II/B – GTP (For Transformer Losses)

Bidders must submit the 'Time schedule for completion of supply' as per Schedule- I/A, List of Special Tools & Tackles (if required) and 'Past experience' as per Schedule- I/C during verification of documents.



The detail 'Guaranteed Technical Particulars' as per Schedule-I/B is required to be furnished during drawing approval stage in the event of order.

## 32.0 WARRANTY/GUARANTEE

Whether or not the equipment has been installed under his supervision, Contractor/Supplier shall be agreeable to the 'Warranty / Guarantee' Clause as stipulated herein.

The main equipment (i.e. Transformer), along-with its fittings and accessories, Transformer oil, Fibre optic temperature sensor (if applicable), spares as well as the Fire prevention and extinguishing system and its fittings and accessories covered under the tender shall be guaranteed for performance and quality for a period of five (5) years from the date of delivery of complete set of equipment at respective sites & satisfactory inspection thereof by Owner's representatives. In case any defect in the equipment/material is found within this guarantee period, the same will be replaced / repaired by the supplier free of cost. If for the purpose of replacement / repair, the equipment / material is required to be dispatched to supplier's works, all charges towards transportation, insurance, packing ,etc. will be borne by the supplier for to & fro dispatches.

In case the transformer fails within the above guarantee period, the same may be taken back to supplier's works for repairing / replacement against submission of Indemnity Bond having value equal to the cost of the transformer. All activities like transportation, repair / replacement, testing, transportation back to the site shall be carried out by the supplier, free of cost.

The Security Deposit Bank Guarantee shall be valid covering the above guarantee period of five years plus six months claim period thereafter and shall be furnished within 30 days of issuance of Purchase Order / Work Order.

The relevant clauses of General Condition of Contract is modified to the extent mentioned above.



### 33.0 SPECIFICATION OF REMOTE TAP-CHANGER CONTROL PANEL (DIGITAL)

#### 1. SCOPE :-

This standard covers specification and acceptance norms for Remote Tap Changer Control System (Digital RTCC) cum Transformer Monitoring panel for control and monitoring of cooling equipment, condition monitoring equipment and OLTC control of power transformers. Digital RTCC relay should be microprocessor based adopting the latest state of the art design & technology with in-built large LCD Display (or better) for ease of programming and viewing. The Digital RTCC relay should provide facilities such as transformer cooler control & data logging, control of OLTC & remote tap position indication at local/remote end, temperature indication, alarms & trips, emergency overload control, recording of accumulated “use of life”, local display of status of control and alarm function etc. The relay shall be suitable for communication to SCADA/SAS over IEC-61850 protocol.

#### 2. Reference standards IS 3231 / IEC 60255/ IEC 61850/ IEC 60068.

#### 3. Panel shall have following constructional features & parameters: -

3.1. Exterior – Light gray to shade No. 631 of IS 5 of Semi-Gloss.

3.2. Interior – White Enamel Gloss.

3.3. Degree of protection IP52 or better.

3.4. Material – 2 mm (min.) thick sheet steel (CRCA) as per IS 513. However, the Frame, load bearing support/structure, relay/meter etc. mounted sheet shall be 2.5 / 3mm sheet steel (CRCA). Front door may be glass with steel frame -- as per approved drawing. All access doors shall be provided with channel rubber/neoprene gaskets.

3.5. All power supply fuses and links terminals are to be shrouded.

3.6. Panel wiring shall be done with PVC 2.5 mm<sup>2</sup> copper wire of 1.1 KV grade (FRLS type).

3.7. PT Supply 110 V AC  $\pm$  10 %, 50 Hz; CT Supply 1 A / 5 A (site selectable).

3.8. Panel/Relay shall be equipped with Keypad Push Button type or Touch Screen.

3.9. The RTCC Panel shall house actuating switch for electrical raise/lower control, tap position indicator, signal lamps for ‘Tap change in progress’ and ‘Tap changer out of step’ etc. and all other auxiliary devices for remote electrical control of the OLTC.

3.10. For remote tap position indicator, the dual output type OLTC transducer shall be provided



in the RTCC panel. One of the outputs of this transducer shall be used for local indication of tap position in RTCC panel and other output (4-20mA) shall be used for SAS/RTUs/SCADA system.

- 3.11. For remote OTI & WTI, the dual output type transducer shall be provided separately in the RTCC panel. One each of the output of this transducer shall be used for Remote OTI and Remote WTI in RTCC panel and other output (4-20mA) shall be used for SAS/RTUs/SCADA system.
- 3.12. Provision shall be made for remote control and monitoring of OLTC. Remote operation shall be possible from Automatic transformer tap changer cum monitoring IEDs mounted in Transformer RTCC panel over IEC 61850 protocol. RTCC shall be digital RTCC (Numerical Relay based control and monitoring & SCADA enabled) as per relevant IS/IEC Standard.
4. Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-built large LCD (or better) display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer/location, it could be customized to suit site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT/VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.
5. It shall be possible to communicate/integrate with all digital RTCC relays of different make located at different locations in the substation by making hardwire and using IS/IEC 61850 communication link. The integration of existing conventional RTCC panel with digital RTCC panel of different make shall also be possible.
6. The digital RTCC relay shall have Raise/Lower push buttons, Manual/ Automatic mode selection feature, Local/Remote selection feature, Master / Follower/ Independent/ Off mode selection feature for control of OLTC. Touch screen option in the relay (instead of electrical push button/switch) is also acceptable.
7. Digital RTCC relays shall communicate with SAS/SCADA using IEC 61850 through fibre optic port to monitor, parameterize and control the OLTC. Dual redundant FO port shall be provided. Any



software required for this purpose shall be supplied and commissioned. The supplied software shall not have restriction in loading on multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time.

8. The relay shall incorporate an under voltage / over voltage blocking facility which shall make the control inoperative if voltage falls / rises by percentage value of set point value with automatic restoration of control when nominal voltage rises / falls to value.
9. The relay shall have facility to compensate the VT and CT-errors.
10. The relay shall have facility to register the tap changer statistics. In the statistics mode, the relay shall display the no. of tap changing operations occurred on each tap.
11. The relay shall have facility to record the voltage and current with respect to time.
12. The relay shall have suitable interface to make communication with higher level SCADA/SAS system over IEC61850 protocol. Any software or CID/ICD file required for the purpose shall be supplied. The supplied software shall not have restriction in loading into multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of connected transformer online in real time.
13. The Digital RTCC relay shall have **additional** programmable Binary Inputs (minimum 8 Nos.) and additional Binary outputs (minimum 8 Nos.) for future use. It shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement.
14. I/Os from/to SCADA for annunciation, control & monitoring of the transformers, as indicated here are minimum and indicative. The bidder shall indicate in the offer any other I/Os, if necessary, for satisfactory operation of the equipment. However, the Purchaser shall approve the same.

#### 14.1. SCADA I/O:

The bidder shall consider following minimum I/O to be communicated to SCADA in addition to conventional alarm system.

- i) Oil temp High – Alarm
- ii) Oil temp High – Trip
- iii) Oil temp normal - Indication
- iv) Winding Temp High – Alarm (HV & LV)





- v) Winding temp High –Trip (HV & LV)
- vi) Winding Temp Normal – Indication
- vii) Dissolved Gas High – Alarm (if applicable)
- viii) Dissolved Gas High – Alarm (if applicable)
- ix) Dissolved Gas Analyser Fail – Alarm (if applicable).
- x) Buchholz Relay – Alarm
- xi) Buchholz Relay – Trip
- xii) Pressure Relief device operated for both PRD device (Main tank)
- xiii) Pressure Relief device operated for PRD device (OLTC)
- xiv) Oil surge relay operated for OLTC
- xv) OLTC circuit healthy
- xvi) OLTC in progress.
- xvii) OLTC failed to operate.
- xviii) OLTC motor tripped.
- xix) OLTC AC Supply Fail
- xx) OLTC Local / Remote selector switch position.
- xxi) OLTC Out of Step Indication
- xxii) OLTC Mechanism Stuck up
- xxiii) OLTC upper limit reached.
- xxiv) OLTC lower limit reached.
- xxv) OLTC Operation Auto Mode
- xxvi) Tap position on 'N'
- xxvii) Transformer –N is master.
- xxviii) NIFPS operated.

14.2. The bidder shall consider following minimum Analog Inputs (4-20mA) to be communicated to SCADA with additional 08 nos Analog inputs provision:-

- a. Tap position indication.
- b. HV Winding Temperature indication.
- c. LV Winding Temperature indication
- d. Oil Temperature indication.



14.3. The digital RTCC relay shall be equipped with 08 nos (4-20mA) Analog outputs for use.

14.4. Following minimum indication/alarm shall be provided in digital RTCC relay either through relay display panel or through relay LEDs and also through Binary output:

14.4.1. INCOMPLETE STEP alarm

14.4.2. OLTC motor overload protection alarm

14.4.3. Supply to DM Motor fail

14.4.4. OLTC IN PROGRESS alarm

14.4.5. OLTC Upper/Lower limit reached alarm.

14.4.6. 415V Main AC supply fail alarm

14.4.7. 415V Standby AC supply fail alarm

14.4.8. Local/Remote Selector switch position in DM box

14.4.9. OLTC Tap position indications.

14.4.10. Independent-combined-remote selector switch positions of CMB

15. The relay shall be capable of retaining its information & configuration in the event of a power failure.

16. The relay shall have security levels to limit access to unauthorized user.

17. The relay shall have self-check of power on and shall continually monitor all functions and the validity of all input values to make sure the control system is in a healthy condition. Any monitoring system problem shall initiate the alarm.

18. 50 × 6 mm copper ground bus shall be provided on the panel extending along the entire length of the assembly. The ground bus shall have two-bolt drilling with GI bolts and nuts at each end to receive Owner/Purchaser's ground connection.

**19. Commissioning & Training:**

19.1. The commissioning shall include programming and testing of the relay in line with approved schematics. Time synchronization and communication of RTCC relays over IEC61850 protocol to upper-level system is to be done during the visit. Services shall also include demonstration of all functions of relay & one-time training to the user for successful operation of the relay.

19.2. The supplier shall offer the price of services (*as included in the price of item – Digital RTCC*) on each relay basis considering two man-days for each relay, however it is supplier's



responsibility to meet the customer satisfaction for the above service within the time frame.

19.3. Necessary site readiness checklist to be prepared by the vendor and given to end user for ensuring the readiness of site before visiting.

19.4. Maximum time allowed for deputation of engineer to the site cannot exceed 1 week after request generated.

19.5. Vendor to obtain completion certificate/MOM from the end user after the visit and furnish for final acceptance.

**20. ROUTINE TESTS AS PER RELEVANT IS/IEC STANDARDS:-**

20.1. Power frequency at 2 KV for 1 minute

20.2. Insulation resistance.

20.3. Functional tests (as per vendor's recommendation & purchaser requirement)



## 34.0 SPECIFICATION OF NITROGEN INJECTION FIRE PREVENTION AND EXTINGUISHING SYSTEM FOR LARGE CAPACITY OIL-FILLED TRANSFORMERS

### 1 GENERAL DESCRIPTION

Each oil filled transformer / reactor shall be provided with a dedicated Nitrogen Injection type Fire Protection System (NIFPS). The NIFPS shall be PLC based and SCADA compatible with at least two nos. of FO ports and RS485 communication facility.

Nitrogen injection system shall be used to prevent the transformer explosion and possible fire, in the case of internal fault and as such acts as a fire preventer. In certain cases, tank explosion cannot be prevented and transformer oil catches fire. In such cases and also in the event of fire by external causes, it shall act as a firefighting system. In either way, it shall protect the transformer and eliminate or minimize the post fire damages. Thus, System shall protect the transformer tank from explosion and also transformer, OLTC and cable box from fire. The system operation shall be automatic and also be made to operate with remote control from control box and manually from extinguishing cubicle in the event of power loss.

### 2 Operation

On receipt of signals, Differential protection parallel with Fire detector, Buchholz (surge) parallel with PRV and transformer/reactor isolation signals, a predetermined quantity of oil drain shall commence and simultaneously Nitrogen shall be injected at a pre-determined flow rate to create stirring action and to bring down temperature of top oil surface below ignition point and shall extinguish fire within shortest possible time. Transformer Conservator Isolation Valve (TCIV) shall block oil passage and isolate conservator tank oil and shall prevent escalation of fire.

#### Operational Controls

The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

#### (A) Prevention of transformer from explosion and fire:

To prevent transformer from explosion and fire in case of an internal fault, signals given by



operation of Electrical protection relays (Differential/Restricted earth fault) and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

**(B) Prevention of transformer from fire:**

In case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

System shall have following characteristics:

- System shall operate in Automatic, Remote and Manual modes in the event of power failure.
- System shall have provision of testing on live transformer to ensure healthiness at all times.
- System shall have interlock to ensure operation of system only after transformer electrical isolation to avoid nitrogen injection in energized transformer.
- System shall have mechanical locking arrangement for nitrogen release system as well as oil drain to avoid unnecessary operation during maintenance and /or testing of the transformer /or system in Machine control unit.
- System shall have provision to monitor nitrogen injection pressure as well as cylinder pressure.
- Pressure monitoring switch for back-up protection for nitrogen release as redundancy to first signal of oil draining commencement for nitrogen release shall be provided.
- System shall have individual mechanical release device and provision for oil drain to operate manually in case of operation DC supply failure in oil release unit of machine control unit.
- System shall have individual mechanical release device and provision for nitrogen release to operate manually in case of operation DC supply failure in gas release unit of machine control unit.



- System shall have oil leakage detection and alarm mechanism in order to avoid unwanted oil leakage from the transformer tank through the fluid oil drain pipe located in cubicle.
- Nitrogen release scheme shall be designed with exhaust port in such way that the nitrogen gas shall not enter the energised transformer/reactor tank even in case of passing/leakage of valve.
- Individual system component/equipment should be working with Station DC voltage. AC-DC/DC-DC converter shall not be used for reliable operation.
- All outdoor panels / Equipment shall be IP55 protection class.

Pipe layout of Nitrogen Injection system as suggested by supplier of Nitrogen injection system shall be provided. **Installation shall be done in presence of OEM representative.**

### **3 Major System Components**

Nitrogen injection fire protection system shall broadly consist of the following components. However, all other components which are necessary for fast reliable and effective working of the fire protective system are also provided.

- (a) Fire Extinguishing Cubicle (FEC):** Cubicle shall be suitable for outdoor as well as indoor installation. It shall have hinged split doors fitted with high quality tamper proof lock. Cubicle shall contain nitrogen gas cylinder, mechanism for oil drain and nitrogen release with essential back up of pressure switch for operation along with control unit.

The FEC 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)

The degree of protection shall be IP55 or better.

The following items shall be provided in the FEC (list is indicative & not exhaustive):

- a) Nitrogen gas cylinder of sufficient capacity with pressure regulator and falling pressure electrical contact manometer with adequate adjustable NO contacts.
- b) The Nitrogen scheme shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/leakage of valve.
- c) Pressure regulator shall have safety relief valve device for higher temperature compensation.



- d) Electro mechanical Machine control unit for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas.
- e) Mechanical release device for oil drain to operate manually in case of DC failure shall be provided in Oil release unit.
- f) Mechanical release device for nitrogen release to operate manually in case of DC failure shall be provided in gas release unit.
- g) Pressure monitoring switch for back-up protection for nitrogen gas release.
- h) Limit switches for monitoring of the system.
- i) Butterfly valve with flanges on the top of panel for connecting fluid oil drain pipe and nitrogen injection pipes for transformer/reactors.
- j) Panel lighting (LED Type).
- k) Fluid Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

**(b) Control box:** shall be placed in the control room for monitoring system operation, automatic control and remote operation. All individual components, instruments shall work on station DC supply. Following alarms, indications, switches, push buttons, audio signal etc. shall be provided:

- System on
- Oil drain valve closed
- Gas inlet valve closed
- TCIV closed
- Oil drain valve open
- Extinction in progress
- Cylinder pressure low
- Differential relay trip
- Fire detector trip
- Buchholz relay trip
- PRV / RPRR trip
- Master (86) relay of Transformer/reactor trip
- System out of service



- Auto / Manual / Off
- Extinction release on / off
- Lamp test
- Visual/ Audio alarm
- Visual/ Audio alarm for DC supply fail
- Fault in cable connecting fault fire 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

Suitable provision may be made in the control box, for monitoring of the system from remote substation using the substation automation system. The control box shall have one IEC 61850 compliant IED, wherein operation of all the major components of NIFPS shall be logged in as time tagged events for analysis and evaluation of operation of NIFPS. Two FO ports shall be provided for connection with SAS.

**(c) Transformer Conservator Isolation Valve:** shall be fitted in the conservator pipe line, between conservator and buchholz relay which shall operate for isolating the conservator sensing abnormal flow of oil due to rupture / explosion of tank or bursting of bushing including tank depressurization during system operation. The valve will not isolate conservator during normal flow of oil during filtration or filling or refilling of oil, locking plates shall be provided with handle for pad locking to ensure no movement of valve position during service and filter position. It shall have proximity switch for remote alarm and indication, glass window for visual inspection similar to buchholz glass inspection window for physical checking of the status of valve. The TCIV shall 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. TCIV shall operate on flow of oil and electrical supply shall not be used for operation. Fire survival cable connecting TCIV shall be terminated in transformer marshalling box.





(d) **Fire detectors:** shall be specially designed to generate signals after sensing higher temperature. The system shall be complete with adequate number of fire detectors fitted on the top cover of the transformer / reactor oil tank.

(e) **Piping:** Heavy duty pipe connecting the transformer/reactor tank for oil drain and for nitrogen injection shall be provided. Pipes connecting oil tank laid underground shall be preferably be galvanized, medium duty

(f) **Cables:** Fire survival copper cables (capable to withstand 750° C.), 1100V grade, Fire Retardant Low Smoke (FRLS) copper cable of minimum wire size of 12 core x 1.5 sq. mm and 4 core x 1.5 sq. mm size shall preferably be used for interconnection. Not more than two wires shall be connected to a terminal. Sufficient spare terminals shall be provided.

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.

(g) **Signal box**

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

**4 NIFPS Manufacturer shall facilitate following provisions for retrofitting job (If applicable):**

(a) Oil drain opening with gate valves of suitable size on transformer tank at upper portion.

(b) Nitrogen injection openings with gate valves on transformer tank at bottom side of tank of suitable size and adequate numbers.

(c) For fixing TCIV in conservator pipe between Buchholz relay and conservator tank.

(d) Fire detector brackets on transformer / reactor tank top cover.

(e) Mounting support frame on tank side wall for signal box.

(f) Spare potential free contacts for activating the system i.e. in differential relay, Buchholz relay, Pressure Relief Device / RPRR, Circuit Breaker of transformer/reactor or as required.



## 5 TECHNICAL PARTICULARS

Fire extinction period from commencement of nitrogen injection	30 secs.(Max.)
Total time duration from activation of fire protection system to bring oil temperature below flash point	30 minutes (Max.)
Fire detectors' (quartz bulb) heat sensing temperature	141 deg. C
Transformer Conservator Isolation valve setting for normal operation (valve should not close) to ensure no obstacle for transformer breathing.	as per OEM design recommendation/calculation ***
Transformer Conservator Isolation valve setting for operation during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing / oil drain during system operation	as per OEM design recommendation/calculation ***
Capacity of nitrogen cylinder	OEM have to design and submit design Calculations for required nitrogen cylinder capacity volume in cubic meter at required pressure and minimum cylinder pressure required to be maintain.***
<b>Power supply:</b> a)For Control Box b) For Fire extinguishing cubicle for lighting	a) 220 V DC. b) 230V AC

**NOTE:- \*\*\* Means the same would be finalised during detailed Engineering.**

## 6 TEST REPORTS

Test report of NIFPS issued by NABL accredited laboratory shall be provided.

## 7 SUPERVISION, TESTING & COMMISSIONING

Supervision of OEM representative will be required during erection, testing and commissioning of the whole system. Successful bidder / Contractor shall ensure that Supervision of Installation & Commissioning of above Fire prevention & extinguishing system by their own representative without any extra cost impact to DVC.



The bidder shall give complete details of the entire system. Test will be carried out on individual equipment of the system and on the total system in the original supplier's workshop in presence of purchaser's representative.

**Bidder shall also arrange to demonstrate the extinguishing of actual fire by the firefighting system (live demo) on one sample in presence of purchaser's representative.**

The bidder / manufacturer shall ensure that fire prevention and extinguishing system offered is full proof and reliable. Supervision of installation, testing, commissioning OR retrofitting job of the fire protection system shall be done in presence of OEM representative of NIFP system and it will be valid for execution up to Twelve (12) months from the date of supply of NIFP System.

## 8 DRAWING AND MANUALS

After awarding of contract, relevant drawings like detailed OGA layout drawing along with the main equipment (transformer) drawing indicating dimensional details of the system and complete Bill of Materials including location and size of plinth for cubicle and recommended capacity of oil soak-pit shall be submitted for purchaser's approval. The vendor shall also provide the drawings of **Foundation / installation setup drawing (Civil related) suitable to site condition.**

**03 (Three) sets of all the above drawings and 03 (Three) sets of Operation and Maintenance Instruction Manual shall be submitted for purchaser's use with an electronic copy.**

**Note :** The fire prevention and extinguishing system shall work on the "Oil drain, Nitrogen Injection and Stir" method. The system shall operate correctly during internal fault in the transformer or external fire on transformer, which includes fire due to bursting of transformer bushings.

However, bidder shall confirm whether it is advisable to initiate the system even when transformer is not electrically isolated due to stuck breaker problem etc.

The protection system shall be compatible to be hooked on to the SCADA or fire alarm system. Suitably spare contacts shall be made available for operation of fire system. System using microprocessor, micro controller shall be given preference.



All valves used in system shall preferably be stainless steel ball / butterfly type. Limit switches shall be provided wherever required.

The connecting cables shall be fire retardant low smoke (FRLS) armoured cable. Cables passing along the top of the transformer shall be the fire survival (FS) type.

The remote control panel, to be mounted inside the control room shall accommodate the necessary control units, operating switches push buttons etc. and also alarm annunciation unit.

The bidder shall, furnish the complete details including bill of materials of the fire prevention and extinguishing system offered. The list of all accessories including FRLS, fire survival cable, pipes, valves, sensors, control cubicle, nitrogen gas cylinder etc. shall be listed out and provided. However cable required for interconnection between Fire Extinguishing Cubicle & its remote Control Panel is not within the scope of the manufacturer.

The bidder / manufacturer shall ensure that fire prevention and extinguishing system offered is full proof and reliable. Installation, testing and commissioning of the fire protection system shall also be in the successful bidder's scope.

## 9 FACTORY ACCEPTANCE TEST

The bidder shall give complete details of the entire system. Test will be carried out on individual equipment of the system and on the total system in the original supplier's workshop in presence of purchaser's representative.



### 35.0 SPECIFICATION OF FIBRE OPTIC TEMPERATURE SENSOR :

*(If specified in Bid Price Schedule)*

In addition to WTI & OTI, Optical Sensors are to be used for hotspot temperature measurement. System shall be of proven technology. The temperature sensing tip along with the fibre optic cable shall be robust and of an already type tested design. The Sensor will be mounted inside a tamper proof & mechanically protected disk allowing efficient and secure mounting for perfect positioning of the Sensor on the measuring surface / medium.

Probes shall be all silica, Teflon jacketed fibre with perforations / slits in outer jackets and be able to be completely immersed in hot transformer oil. It should withstand the transformer insulation drying process. The probes shall not get damaged during filtration of the transformer. The fibre with Teflon jacket shall be strong enough to withstand the severe conditions prevailing inside an EHV Transformer. The probes shall meet the requirements to eliminate the possibility of partial discharge in high electrical stress areas in the transformer. Details of the relevant tests should be provided.

One no Optical sensor shall be used for each phase of HV, two nos. for each phase of IV / LV windings, two nos. for top oil temperature and one no for bottom oil temperature i.e minimum 12 nos. optical sensor shall be provided in the transformer. However, these locations are indicative only and to be finalized during detailed engineering. Sensors will be installed at the hottest spots as per the thermal modelling to be furnished by the Manufacturer of the Transformer. All the temperatures shall be displayed in the Signal Conditioner or the temperature measuring unit.

This optical sensors measuring system shall be of direct measurement non calibrating type. Temperature range of the system should be -30°C to +200°C & accuracy of +/-2°C and the entire system shall be capable of withstanding all Routine and Type Tests of the transformer to be conducted at the Manufacture's Works. The Temperature Rise tests shall be carried out with the fibre Optic Sensors already installed in the Transformers and temperature data for all probes will be recorded and stated in the test report.

All the Fibre Optic Cables will be brought out of the main tank through a leak proof feed through plate installed on the tank wall and Pressure Test Report towards leak proofing



of the assembly shall be submitted. The external fibre optic cables shall be routed through flexible SS conduits with large bend radiuses for termination to temperature measuring unit.

The Signal Conditioner or the temperature measuring unit shall be housed in a separate enclosure having degree of protection of IP65 and shall be capable to retain temperature data for at least 90 days of one reading/15 minutes/sensor and shall have facility to download these data. The monitor shall offer user programmable temperature alarm outputs with programmable relays plus one System Status Relay. The monitor will have RS 485, Ethernet (RJ45) & USB communication ports and should allow communication with the SCADA system by using Modbus Protocol & IEC 61850. User friendly Software should be provided to allow easy configuration of the monitor and for data retrieval.

4-20 mA analog output of each channel shall be provided. Temperature of each sensor shall be displayed at the remote digital RTCC panel using this analog signal. This remote monitor on digital RTCC panel shall be supplied by the manufacturer (interconnecting cable to carry the 4-20 mA signal from local monitor to digital RTCC panel will be in the scope of the Bidder).

The relevant tests & certifications from reputed independent Test Labs must be furnished during detail engineering along-with the GTP.

Commissioning of the complete set of fibre Optic Temperature Sensors shall be undertaken by the Manufacturer at their own arrangement without any additional cost implication to the Purchaser.



### 36.0 SPECIFICATION OF 'ON LINE DGA AND MOISTURE CONTENT MONITOR' :

*(If specified in Bid Price Schedule)*

1. The Monitor shall be a microprocessor based Intelligent Electronic Device (IED), designed to continuously detect and measure dissolved gases and water content, even at very low concentrations, in Transformer Oil. It should be easy to install.
2. The monitor shall be designed for permanent outdoor use in high voltage sub-station environments, for ambient temperatures of -20°C to 55°C and oil temperatures of -20°C to + 115 °C.
3. The monitor shall be suitable to detect and measure dissolved gases in ppm, without significant interference from other fault and atmospheric gases. The monitor shall also be suitable to detect Water Content measured in ppm or % RS (Relative Saturation).
4. The instrument shall be able to extract, detect, analyse and display the dissolved gases in insulating oil as specified in IEEE C 57-104-2008 and IEC 60599-2007. All the fault gases i.e. H<sub>2</sub>, CH<sub>4</sub>, C<sub>2</sub>H<sub>2</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, CO, CO<sub>2</sub>, O<sub>2</sub>, etc. and moisture concentration shall be individually measured and displayed. The minimum detection limits of the instrument for the above gases shall strictly meet the requirement of relevant clauses of IEC-60567-2011 (read with latest amendments).
5. The respective sensors of the monitor shall have long lifetime in oil. The sensors shall be able to withstand pressure from vacuum to 14 psi or the maximum design pressure of the main tank of the transformer.
6. **Technical Parameters:**

Sr. No.	Parameters	Requirements
a)	The measurement range / Output:	



	Hydrogen and other Dissolved Gases in oil	H <sub>2</sub> : 20 to 2000 ppm, with 4 – 20 mA output Minimum detection limits of dissolved gases shall be as per the requirement of IEC-60567-2011 (read with latest amendments) with 4 – 20 mA output.
	Water Dissolved in oil	0 to 100% RS, with 4 – 20 mA output
b)	Alarm / Indication	
	Fault Gases	Programmable Relays with contacts
	Water	Programmable Relays with contacts
c)	Environment	
	Operating Ambient Temperature	– 20 to + 55 °C
	Operating Oil Temperature	– 20 to + 115 °C
d)	Pressure Withstand (Oil side)	Full Vacuum to 14 psi or the maximum design pressure of the main tank of the transformer.
e)	Exterior enclosure and components	Shall be made of corrosion proof material & conforming to IP-55 or better
f)	Communications	RS–232/485 ports and suitable for Ethernet connectivity

7. The alarm & values of dissolved gases & moisture shall be displayed at digital RTCC for which accessories required at digital RTCC shall be supplied by the successful bidder. The interconnecting cables to carry the signals from local monitor to digital RTCC will be in the scope of successful bidder.
8. The Monitor shall work on station auxiliary supply. In case other supply is required for the equipment, then suitable converter shall be included. All necessary cable, accessories shall be provided by the supplier.
9. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be IEC 61850 compliant to integrate with SCADA /SAS system. The results shall be compared with the standard pre-set results to indicate the possible severe damage / failure.





10. The Monitor shall be complete with necessary software (if any) for its configuration, downloading of its data & its interpretation (fault indication and fault diagnostics) along with operation & maintenance manual.
11. Online DGA monitor, shall be installed outdoors on transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona and capacitive coupling). The equipment shall be suitable for proper operation in EHV substation environment where switching takes place in the EHV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55 °C ambient temperature and EMI and EMC compatibility.
12. The equipment shall preferably connect to the transformer's main body in two locations. One connection is for the supply of oil from the transformer. Second connection is for the return of the oil to the transformer. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses.
13. The Equipment shall have an automatic Calibration facility at fixed intervals. For calibration if anything is required shall be supplied in adequate quantity along with the Equipment.
14. The relevant tests & certifications from reputed independent Test Labs shall be furnished during detailed engineering along with the GTP.
15. Installation & commissioning at site by manufacturer's representative shall be done free of cost.
16. Functional test of complete set of online dissolved DGA and moisture content monitor along-with accessories to be demonstrated during commissioning stage in presence of Purchaser's representatives.



### 37.0 SPECIFICATION FOR ON-LINE INSULATING OIL DRYING SYSTEM (CARTRIDGE TYPE)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each transformer shall be provided with an online insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This online insulating oil drying system shall be:

- i) Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5 litres/minute).
- ii) The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.
- iii) In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air/ contamination is trapped during commissioning.
- iv) In case, drying system is transported with oil, the oil shall conform to the specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.
- v) Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the online insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.
- vi) The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.
- vii) The equipment shall be capable of transferring data to substation automation system confirming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the contractor for integration with the automation system.
- viii) The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and CD/DVD giving operation procedures of Maintenance Manual & Trouble shooting instructions.



### 38.0 CONDITION CONTROLLED REGENERATIVE MAINTENANCE FREE SILICA GEL BREATHER:

1. The main Transformer tank conservator and OLTC conservator shall be fitted with a Maintenance-Free type silica gel Breather which shall be equipped with a microprocessor control unit and LED status indication.
2. Dehydrating breather's operating principle:  
When the oil conservator breaths-in (e.g. at reduced load), the air flows through a filter made of high-grade steel wire mesh. The equipment fitted with filter & the dust cap, filters the dust, sand and other dirt particles from the air. The filtered air flows through the desiccant chamber filled with colorless, moisture adsorbing pellets and are dehydrated. The dehydrated air rises further via the pipe in the oil conservator. The desiccant is dehydrated by the built-in heating unit which is controlled by sensors, thus obviating the need for periodic desiccant replacement. The dehydrating breather is mounted on the pipe to the oil conservator at a height of 1200 mm approximately from transformer rail top level.
3. Technical Features:
  - 3.1 Material & External Construction of the Breather shall be such that all external parts are suitable for outdoor use & resistive to transformer oil, ultraviolet rays, pollution & salt water and shall work without any trouble for ambient temperature between 0 °C to +80 °C.
  - 3.2 Following LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:
    - a) LED for Power of control unit - ON
    - b) LED for Filter heater- ON
    - c) LED for Anti-condensation heater (of control unit) - ON
    - d) LED & relay contact for "Device Error"
    - e) LED & relay contact for Regeneration active (De-humidification in process)
    - f) Analogue output signal (4-20mA) for the Temperature of air (in filter unit / pipe).
  - 3.3 The Breather shall be equipped with test button which should allow to carry out a self-test and to check the functions like relay circuits, heating or the signal transmission in the control room, etc. at any time.



- 3.4 Control unit shall be equipped with a communication port for downloading the operational data logged by the unit. All necessary software required for downloading and analysing the logger data shall also be provided by the supplier. Supply of Laptop/PC for above software is not envisaged.
- 3.5 The moisture and temperature measurement system (sensor) installed should be modular making it easy to replace the same if at all the same is necessary during the service of breather.
- 3.6 The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied with the equipment.
- 3.7 Degree of Protection shall be at least IP55 for which type Test report shall be submitted. Necessary protective devices shall be provided in order to protect the equipment against over voltages & high-frequency interference.
- 3.8 The control unit shall be equipped with suitable heater to prevent moisture condensation.
- 3.9 The size of Condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.
4. The equipment shall be covered on warranty for a period of 5 years from the date of receipt of complete set of equipment at respective sites & satisfactory inspection thereof by Owner's representatives.. During this period, if the equipment needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of this equipment for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.
5. Condition Controlled Maintenance Free Type Breather of alternate proven technology shall also be acceptable.



## ANNEXURE – A

### **GENERAL SITE INFORMATION**

#### **Location:**

Shall be as per NIT document.

#### **Meteorological Data**

##### **Temperature**

The daily average ambient temperature throughout the year ranges between 5°C/50°C.

The peak ambient temperature is 50°C.

##### **Relative Humidity**

The relative humidity is expected to be between 10% during dry season and 100%max. during monsoon season. The dry seasons means generally the calendar months from November to May and the wet season from June to October of the English Calendar year.

##### **Rainfall**

The daily rainfall ranges 25mm to 75mm per day during the monsoon making an average year rainfall of 1500mm.

##### **Wind**

The maximum wind velocity will be 170 Km/hour. The wind speed and wind loads shall be taken as per the latest IS-875: 'Code of practice for structural safety of buildings, Loading Standards'.

#### **Seismic Loads**

The maximum earthquake may be assumed as 0.075g in the horizontal direction and 0.0375g in the vertical direction. The seismic loads to be considered for the design of the structures should be taken as per the latest IS-1893 'Criteria for earthquake resistant design of structure' and IS-4326 : Code of practice for earthquake resistant construction of buildings.

#### **Atmospheric Conditions**

For equipment design considerations the atmospheric condition shall be taken as laden with industrial, and town gases and with dust in suspension (during dry months, Fog, smoke and mild acids may also be present).



## ANNEXURE - B

### **AUXILIARY SUPPLY SYSTEM DATA**

1. L.T. system (Star point solidly grounded) voltage :  $415 \text{ V} \pm 10\%$  (3 phase),  
1 Phase AC Supply =  $240 \text{ V} \pm 10\%$   
Frequency =  $50 \text{ Hz} \pm 3\%$
  
2. DC supply (ungrounded) Voltage:  
 $250/220 \text{ V} \pm 10\%$   
Short circuit current level : 15 KA



## ANNEXURE – C

### INSPECTION AND QUALITY CONTROL

(Besides guidelines provided by QC&I Deptt. of DVC, separately)

- 1.0 The contractor shall prepare, submit, discuss with the purchaser and finalize based on the said discussions, within sixty (60) days from the Letter of Intent / Award / Acceptance, detailed quality plan in the Proforma approved by the QC&I Dept. of Purchaser, for all components of the equipment manufactured by contractor setting out during the various stages of manufacture the quality practices and procedures to be followed by his quality control department, the relevant reference documents/standards, acceptance level, inspection documentation raised etc. In these quality plans the purchaser will identify 'Hold Points' beyond which work will not progress without his consent in writing. For the components/equipment purchased by the contractor for the purpose of this contract, his purchase specification and enquiries shall call for such quality plans. Along with their proposals the quality plan of the sub-vendor shall be discussed and finalized by the Contractor in the aforesaid manner and shall form part of the purchase order on his sub-vendor. **The Purchaser (DVC) also reserves the right to carryout quality audit and quality surveillance of the system and procedures of contractor's / sub- vendors' quality management and control activities.** However, such audit or quality surveillance by Purchaser shall not relieve the Contractor of any of his responsibilities under the terms of the contract.
- 2.0 Within ninety (90) days from the date of Letter of Intent / Acceptance, the contractor shall furnish the field quality manuals for the various field activities detailing the procedures and inspection check lists for transportation, storage/preservation, erection, pre-commissioning and commissioning activities which will be followed by Purchaser's Erection Contractor. If deemed fit, Purchaser reserves the right to call for contractor's supervision of the equipment erection.
- 3.0 The field quality manuals shall indicate the various assembly/erection/operation tolerance and the limits of deviations for each individual equipment and system.
- 4.0 Purchaser reserves the right to depute Engineers for stage inspection / testing and inspection / testing after completion of manufacture.



## ANNEXURE – D

### **DESIGN CRITERIA FOR 200MVA 3 Ph- AUTO TRANSFORMER** **(WITH UNLOADED TERTIARY)**

- |   |   |  |
|---|---|--|
| 1. RATED CAPACITY (AT Full Load & 50 deg C maximum ambient)                               | : | 200 MVA  |
| 2. Voltage ratio at no Load   | : | 230 KV / 138 KV / 33 KV<br>(HV) (IV) (LV)  |
| 3. Impedance Voltage at normal tap (percent) rated MVA base at 75 deg C (between HV - IV) | : | Principal tap: 12.5%<br>(Tolerance shall be considered as per IEC)<br>Max. Voltage tap: 9.5%<br>Min. Voltage tap: 14.0%<br>The offered transformers shall be designed on the basis of percentage impedance as indicated above. |
| 4. High Voltage connection  | : | Star with neutral brought out through 36 KV HV-n bushing for solid ground connection.  |
| 5. Intermediate Voltage connection  | : | -Do-   |
| 6. i) Tertiary/Low voltage connection   | : | Delta with two-phase windings brought out through 52 KV Bushings for test connections  |
| ii) Stabilizing Duty of Tertiary winding  | : | ⅓ (one-third) equivalent of two winding transformer ratings.   |
| 7. Polarity & Vector Symbol   | : | YNa0d1 – Subtractive   |
| 8. No. of phases & windings   | : | 3-ph., 3-windings.   |
| 9. Frequency and operation  | : | 50 Hz ± 3%   |
| 10. Type of cooling of full rated Capacity  | : | OFAF   |
| 11. Rated capacity OFAF (100%)  | : | 200 MVA  |
| 12. Rated capacity ONAF (80%)   | : | 160 MVA  |
| 13. Rated capacity ONAN (60%)   | : | 120 MVA  |
| 14. Temperature rise limit at full Load rated capacity over ambient of 50C°               | : | 45°C for top oil by thermometer<br>50°C for winding by resistance  |





15. The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 % continuous over-voltage condition it does not exceed 1.9 Tesla at all tap positions.  
Transformers shall withstand without damage, heating due to the combined voltage and frequency fluctuations which produce the following over voltage conditions:

110 % overvoltage continuously  
125 % overvoltage for 1 minute  
140 % overvoltage for 5 seconds

16. Type of construction : Core type oil immersed outdoor type
17. Tap changer : ON load tap for a voltage variation of  $\pm 10\%$  (in steps of 1.25% in 16 equal steps, total position shall be 17(seventeen)) to be provided on HV winding. The design provisions should be kept in such a way that the transformer will be capable of delivering full specified load at  $\pm 10\%$  variation of HV side for continuous operation required for system demand.
18. Short circuit rating : Dead short circuit at the terminal of any of the winding for 2 (two) seconds.
19. Separated source power frequency : 70 KV  
Voltage for H.V.- neutral end
20. BIL of the windings :  
i) HV - 950 KV<sub>p</sub>  
ii) IV - 650 KV<sub>p</sub>  
ii) LV - 250 KV<sub>p</sub>
21. Power frequency voltage of windings (rms) :  
i) HV - 395 KV  
ii) IV - 275 KV  
iii) LV - 95 KV  
iv) HV-IV-neutral - 70 KV
22.  
a. Insulation level of Bushings  
i) HV side (Anti fog type) : 245 KV, 1250 Amps.  
ii) IV side (-do-) : 145 KV, 1250 Amps.



- iii) LV (Test Bushings) : 52 KV, 1000 Amps.
- iv) HV –Neutral : 36 KV, 2000 Amps.

b. Power frequency 1 min. dry & wet withstands voltage

- i) HV side : 505 KV
- ii) IV side : 305 KV
- iii) LV side : 105 KV
- iv) HV -Neutral : 77 KV

c. BIL of Bushings

- i) HV side : 1050 KVp
- ii) IV side : 650 KVp
- iii) LV side : 250 KVp
- iv) HV -Neutral : 170 KVp

- d. Creepage Distance : 25mm/KV (Minimum)

23. Terminal Arrangement

- a. HV & IV side : Outdoor bushings with Expansion type terminal connector (Extruded type) to Purchaser's ACSR/AAAC Conductor / 2.5" IPS Al Tube suitable to take both for horizontal and vertical take-off. Details to be finalized during engineering.
- b. HV - neutral : Bare outdoor busing terminal suitable for termination of 50mm X 6mm G.I./GS strip/ flat through 36 KV Solid post Insulators.
- c. LV side : Bare outdoor bushing terminal only Terminal connectors shall be as per IS: 5561 and shall be suitable as per system fault level indication herein.

24. Rail gauge

- i) 1676 mm on minor (shorter) axis
- ii) Preferably 3 rails / 4 rails with standard gauge (1676mm) on major axis with provision for fixing the wheels at the different points shall be kept (however, number of rails, location of jacking pads, etc. shall be finalized during detailed engineering stage. Location of Jacking pads shall be such that it should not interfere with loading & unloading from trailer)



25. Parallel operation : The transformers shall be compatible for parallel operation with existing transformers at respective sites. (also Ref. Cl. 10 of TS.)
26. Utility : To be used as interconnecting transformer between two voltage levels. Exchange of Power shall occur either from 220 KV system to 132 KV system or from 132 KV system to 220 KV system.
27. Transformer oil : EHV grade new transformer oil as per Annexure– E of this specification
28. Bushing C.T. details (Phase and Neutral):

a) HV Bushing CT

Core	I	II
Ratio	1000-500/1A	1000-500/1A
Class	PS	PS
$V_k$ (min.)	1000-500V	1000-500V
$I_m$ at $V_k$ (max.)	25/50mA	25/50mA
$R_{CT}$ at 75°C (max.)	4 / 2 $\Omega$	4 / 2 $\Omega$

b) IV Bushing CT

Core	I	II
Ratio	1000-500/1A	1000-500/1A
Class	PS	PS
$V_k$ (min.)	1000-500V	1000-500V
$I_m$ at $V_k$ (max.)	25/50mA	25/50mA
$R_{CT}$ at 75°C (max.)	4 / 2 $\Omega$	4 / 2 $\Omega$

c) Neutral CT

Core	I	II	III
Ratio	1000-500/1A	1000-500/1A	1000-500/1A
Class	PS	PS	PS
$V_k$ (min.)	1000-500V	1000-500V	1000-500V
$I_m$ at $V_k$	25/50mA	25/50mA	25/50mA



(max.)  
 $R_{CT}$  at  
 $75^{\circ}\text{C}$   
(max.)

$4 / 2 \Omega$

$4 / 2 \Omega$

$4 / 2 \Omega$

Note: However, the above details of NCT are subject to alteration during detailed engineering.

29. Digital RTCC Panel : The transformer shall be supplied with digital RTCC Panel as per specification
30. Life of Transformer to be considered in design : 25 Years (Min.)
31. EQUIPMENT COLOUR CODE : The following code of practice shall be adopted for colour finish of the respective electrical equipment :

Equipment	Color	Finish
<b>a. Transformers</b>		
Installed outdoor (i.e., oil immersed Transformers)	IS5 – 632 of IS-5 (Dark admiralty grey)	Mat
<b>b. Misc. Panel &amp; JB's etc.</b>		
Exterior	IS5 – 631 of (light Grey)	Semi gloss
Interior	White / Off-white	Semi gloss

32. Core to bolt insulation test voltage : 2.5KV A.C. for 1(one) min
33. Maximum noise level at rated voltage, : 75 dB  
principal tap & no load and all cooling active
34. The transformer shall be designed with particular attention to the suppression of maximum Harmonic voltage, specially the third harmonic and fifth harmonic so as to minimize Interference with communication circuit.
35. Mounting of Cooling Equipment : The transformer shall be compact as far as possible and provision shall also be made to mount the cooling equipment (i.e. radiators, cooling fans and pumps sets) in either side of the transformer so that the same can be erected on either side of the transformer depending on the availability of space of existing Switch yard of DVC.  
220 KV Bay width, i.e. distance between centre lines of two respective gantries is 16 Mtr. Wherever applicable,



transformer foundation is to be matched with existing one without any additional cost implication to the employer.

36. Foundation Design

: The foundation details shall be provided by the manufacturer.

It is envisaged to design the transformers in such a way so that foundation of offered transformers shall match with the existing foundation, where ever applicable as per Owner's discretion.

It is the responsibility of the Manufacturer to arrange site visit and take necessary measurement of existing Transformer foundation and prepare the final foundation drawings of offered Transformers accordingly to DVC.

Foundation Drawing submitted by the Manufacturer for approval without existing foundation details, where-ever required, shall not be entertained.

37. System Fault Level

: Transformer shall be suitable for connection to the system having the following fault level

HV Side	:	50 KA (r.m.s.) for 1Sec
IV Side	:	40 KA (r.m.s.) for 1Sec
LV Side	:	25 KA (r.m.s.) for 3Sec

38. Minimum Electrical Clearances in air shall be maintained as per following:

Terminal	Phase to Phase (in mm)	Phase to Earth (in mm)
HV	2350	2150
IV	1430	1300
LV	350	320
Neutral	-	320

39. Maximum Permissible Losses :

- Max. No Load Loss at rated voltage and frequency: 35 KW.
- Max. Load Loss at rated current and at 75°C for HV and LV windings at principal tap position: 260 KW.



iii) Max. Auxiliary Loss at rated voltage and frequency: 8 KW.

**Notes:**

- i) No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV impedances.
- ii) Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
- iii) External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3.



## ANNEXURE – E

### GENERAL TECHNICAL PARAMETERS OF TRANSFORMER OIL

#### Unused Inhibited Insulating Oil Parameters

Sl. No.	Property	Test Method	Limits
<b>A</b>	<b>Function</b>		
1a	Viscosity at 100 °C	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm <sup>2</sup> /s
1b	Viscosity at 40 °C	ISO 3104 or ASTM D7042	(Max.) 12 mm <sup>2</sup> /s
1c	Viscosity at -30 °C	ISO 3104 or ASTM D7042	(Max.) 1800 mm <sup>2</sup> /s
2	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3	Pour point	ISO 3016	(Max.) -40 °C
4	Water content a) for bulk supply b) for delivery in drums	IEC 60814 or ASTM D1533	(Max.) 30 mg/kg 40 mg/kg
5	Electric strength (breakdown voltage)	IEC 60156	(Min.) 30 kV (new unfiltered oil) / 70 kV (after treatment)
6	Density at 20 °C	ISO 3675 or ISO 12185 or ASTM D 7042	Max. 895 Kg/m <sup>3</sup>
7	Dielectric dissipation factor (tan delta) at 90 °C	IEC 60247 or IEC 61620	(Max) 0.005
8	Negative impulse testing KVp @ 25 °C	ASTM D-3300	145 (Min.)
9	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max. Aromatic : 4 to 12 % Paraffins : <50% & balance shall be Naphthenic compounds
<b>B</b>	<b>Refining/Stability</b>		
1	Acidity	IEC 62021-1 or ASTM D974	(Max) 0.01 mg KOH/g
2	Interfacial tension at 27 °C	ISO 62961 or ASTM D971	(Min) 0.043 N/m
3	Total sulphur content	ISO 14596 or ISO 8754	0.05 % (Max.) (before oxidation test)
4	Corrosive sulphur	IEC 62535  ASTM D1275B	Non-Corrosive on copper and paper  Non-Corrosive
5	Presence of oxidation inhibitor	IEC 60666 or ASTM D2668 or D4768	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives. Supplier should declare presence of additives, if any.
6.	2-Furfural content	IEC 61198 or ASTM D5837	25 Microgram/litre (Max.)



<b>C Performance</b>			
1	Oxidation stability -Total acidity -Sludge - Dielectric dissipation factor (tan delta) at 90degC	IEC 61125 (method c) Test duration 500 hour  IEC 60247	Max 0.3 mg KOH/g Max 0.05 % Max 0.05
2	Oxidation stability	ASTM D2112 (a)	220 Minutes (Min.)
<b>D Health, safety and environment (HSE)</b>			
1	Flash point	ISO 2719	(Min.)135deg C
2	PCA content	BS 2000 Part 346	< 3%
3	PCB content	IEC 61619 or ASTM D4059	Not detectable (< 2 mg/kg)

All the tests will be conducted by the manufacturer at their works as per relevant IS/IEC/Technical Specification of the Tender Document.





## ANNEXURE – F

### **REFERENCE STANDARDS FOR TRANSFORMERS AND CONNECTED EQUIPMENT AND DEVICES.**

<u>Sl. No.</u>	<u>IS/BS</u>	<u>TITLE</u>
1.	IS:5	: Colours for ready mixed paint
2.	IS:104	: Ready mixed paint brushing zinc chrome priming
3.	IS:109	: Copper
4.	IEC: 60296	: Specification of Insulation oil
5.	IS:642	: Varnish medium for aluminium paint
6.	IS:649	: Methods of testing steel sheets for magnetic circuits of power electrical apparatus.
7.	IS:1271	: Clarification of insulating materials for electrical machinery and apparatus in relation to their stability in service.
8.	IS:1666	: Paper covered rectangular copper conductors for transformer windings.
9.	IS:1866	: Code of practice for maintenance of insulating oil.
10.	IS:1885 (Pt- II)	: Electro technical vocabulary- Machines and Transformers
11.	IS:1886	: Code of practice for Installation and Maintenance of Transformers.
12.	IS:2026 (Pt I-IV):	Specification for Power Transformer
12A.	IEC 60076	: Standard for Power Transformer (all Parts)
13.	IS:2070	: Method of Impulse Voltage Testing
14.	IS:2071	: Method of high Voltage Testing
15.	IS:2099	: High Voltage Porcelain Bushing
16.	IS:2705 (Pt I-IV):	Current Transformers
17.	IS:3347 (Pt I-V) :	Dimension of Porcelain Transformer Bushing
18.	IS:3637	: Gas Operated Relay
19.	IS:3638	: Application Guide for Gas Operated Relay



20. IS:3639 : Fitting & Accessories for Power Transformer
21. IS:4253 (Pt-II) : Cork composition sheet cork and rubber
22. IS:4257 : Dimensions for clamping arrangement for bushing
23. IS:5561 : Electric Power Connector
24. IS:6103 : Method of test for Specific Resistance  
(Resistivity) of electrical insulating liquids
25. IS:6104 : Method of test for Interfacial Tension of oil  
against water by the ring method
26. IS:325 : Induction Motor
27. IS:10593 : DGA Acceptance
28. IS:8468/IEC 60214 OLTC
29. IS:5561 : Terminal Connector
30. BS:698 : Paper for Electrical
31. CBIP : On Transformer Manual
32. IS 1554 : Specification for PVC Insulated (Heavy Duty)  
Electric Cable
33. IS 7098 : Specification for XLPE Insulated PVC sheathed  
Cable
34. Other relevant IS/other approved international Standards like BSS, IEC, ASA,  
VDE
35. Fire prevention & Extinguishing System by Nitrogen (N<sub>2</sub>) Injection  
method covered by this specification shall fully satisfy the  
requirements of the following:-
  - 1) Rule No. 64.2.f (ii) of Indian Electricity Rule, 1956
  - 2) Relevant concerned regulations as laid by Tariff Advisory Committee.
  - 3) Relevant clauses of OIL INDUSTRY SAFETY DIRECTORATE No. OSID-STD-  
173, 1998.



## SCHEDULE – I/A

### **(TIME SCHEDULE FOR COMPLETION OF SUPPLY)**

The Tenderers must submit the 'Bar Chart' /program schedule in respect of following activities along with the tender.

#### **Activities**

- a) Procurement of raw materials
- b) Drawings submission and approval
- c) Fabrication
- d) Assembly
- e) Wiring
- f) Procurement of bought out items
- g) Stage inspection & witnessing test
- h) Inspection of complete equipment and witnessing routine/type/special tests as applicable.
- i) Transportation
- j) Erection & Commissioning (if applicable)

- NOTE:**
1. The bar chart shall be prepared 'in months' with date of issue of 'Letter of Intent / Award / Acceptance' as the base date.
  2. Bar chart shall be submitted for all the transformers covered by this specification and shall be matched with the 'Delivery Schedule' as mentioned in this specification/NIT.

Date :.....

(Signature).....

Place : .....

(Name).....

(Designation) .....

(Common Seal) .....



## SCHEDULE – I/B

### **GUARANTEED TECHNICAL PARTICULARS**

**(TO BE FURNISHED BY THE L<sub>1</sub> BIDDER DURING DETAIL ENGINEERING STAGE)**

#### **I. AUTO TRANSFORMER:**

1. Name & address of manufacturer :
2. Country of origin :
3. Standard specification on which the performance data is based. :
4. Continuous rated output based on temperature limits of 50°C rise over ambient for winding (by resistance) & 45°C rise over ambient for oil (by thermometer for HV/IV/LV....MVA. :
5. Equivalent continuous maximum rating based on IS 2026 standard temperature rise and ambient temperature MVA, HV/IV/LV. :
6. Rated temperature rise over specified peak ambient (50°C in air)
  - a) of oil by thermometer °C rise :
  - b) of winding by resistance °C rise :
7.
  - a) No load voltage ratio :
  - b) Rated frequency :
  - c) No. of phase :
  - d) Phase connection – Vector group :
  - e) Rating of windings under different stages of cooling 

	<b><u>ONAN</u></b>	<b><u>ONAF</u></b>	<b><u>OFAF</u></b>
i) HV			
ii) IV			



iii) LV

8. Exciting current referred to H.V. and 50 CPS at -
- |                           |     |      |   |
|---------------------------|-----|------|---|
| 90 percent rated voltage  | ... | amps | : |
| 100 percent rated voltage | ... | amps | : |
| 110 percent rated voltage | ... | amps | : |
9. Power factor of excitation current at 100 percent rated voltage, 50 CPS - % :
10. **Reactance voltage** (at 75°C) at full load
- |    |                      |   |
|----|----------------------|---|
| a) | HV Winding           | : |
| b) | IV Winding           | : |
| c) | LV Winding           | : |
| d) | HV-IV (200 MVA base) | : |
|    | i) At Tap No. 1      | : |
|    | ii) At Tap No. 9     | : |
|    | iii) At Tap No. 17   | : |
| e) | HV -                 | : |
|    | LV                   | : |
|    | i) At Tap No. 1      | : |
|    | ii) At Tap No. 9     | : |
|    | iii) At Tap No. 17   | : |
| f) | IV - LV              | : |

(All values shall be referred to rated MVA)

11. **Impedance voltage** (at 75°C) at full load :
- |    |                      |   |
|----|----------------------|---|
| a) | HV Winding           | : |
| b) | IV Winding           | : |
| c) | LV Winding           | : |
| d) | HV-IV (200 MVA base) | : |
|    | i) At Tap No. 1      | : |
|    | ii) At Tap No. 9     | : |



- iii) At Tap No. 17 :
- e) HV - LV
- i) At Tap No. 1 :
- ii) At Tap No. 9 :
- iii) At Tap No. 17 :
- f) IV – LV :

**(All values shall be referred to rated MVA)**

12. **Regulation** at full load. (at 75°C)

and following power factors -

- a) 1.00 .. % :
- b) 0.90 lagging .. % :
- c) 0.85 lagging .. % :
- d) 0.80 lagging .. % :

13. **Zero sequence Impedance** (75°C )

i) From H.V. side :

- a) Highest tap ... %
- b) Lowest tap ... %
- c) Normal tap ... %

**(All values shall be referred to rated MVA)**

ii) From IV side :

- a) Highest tap ... %
- b) Lowest tap ... %
- c) Normal tap ... %

**(All values shall be referred to rated MVA)**

14. Withstand time without injury with three phase  
dead short circuit at the terminals .. sec :

15. “Ideal heating time” or the thermal time



constant of

- a) Winding .. Sec :
- b) Transformer .. Hrs :

16. **Core -**

- a) Type of construction (core/shell) :
- b) Material of Core with Grade :  
(Indicate grade whether  
M4, M3 or B or HiB)
- c) Thickness of stamping .. mm :
- d) Flux density at 100 percent  
voltage and 50 CPS .. Tesla :
- e) Flux density at 115% voltage  
and 50 CPS .. Tesla :
- f) Flux density at 125% voltage  
for 1 (one) minute .. Tesla :
- g) Flux density at 140% voltage  
for 5 (five) seconds. .. Tesla :
- h) Insulation between the core laminations :
- i) Type of joint between the core  
limbs and yoke :

17. **Windings -**

- a) Current density in -
  - HV Winding .. Amps per sq mm :
  - IV Winding .. Amps per sq mm :
  - LV Winding .. Amps per sq mm :



b) Type of joints in the windings, if any :

c) Insulation strength of winding with

Impulse full wave –

- |      |      |    |    |   |
|------|------|----|----|---|
| i)   | HV   | .. | KV | : |
| ii)  | IV   | .. | KV | : |
| iii) | LV   | .. | KV | : |
| iv)  | HV-n | .. | KV | : |

Impulse chopped wave –

- |      |      |    |    |   |
|------|------|----|----|---|
| i)   | HV   | .. | KV | : |
| ii)  | IV   | .. | KV | : |
| iii) | LV   | .. | KV | : |
| iv)  | HV-n | .. | KV | : |

Applied voltage test –

- |      |        |    |    |   |
|------|--------|----|----|---|
| i)   | HV – n | .. | KV | : |
| ii)  | IV – n | .. | KV | : |
| iii) | LV     | .. | KV | : |

Induced over voltage test –

- |      |    |    |    |   |
|------|----|----|----|---|
| i)   | HV | .. | KV | : |
| ii)  | IV | .. | KV | : |
| iii) | LV | .. | KV | : |

d) No. of turns per phase of

- |      |            |   |
|------|------------|---|
| i)   | HV Winding | : |
| ii)  | IV Winding | : |
| iii) | LV Winding | : |

e) Minimum clearance through Oil :

f) Type of windings (concentric or sandwich) :





- g) Phase angle position of the LV/ IV :  
(Phase to earth) vector with respect to the HV  
(Phase to earth) vector, assigning positive  
sense to the anti-clock wise rotation. elec. degree

**18. Tap changer**

- a) Type and make of tap changer :
- b) Number of taps provided on the winding :
- c) Number of taps above normal :
- d) Number of taps below normal :
- e) Extreme taps to provide voltage :  
variation above and below  
normal voltage ... (+) ..... % (-)
- f) Each tap to provide voltage variation of .... % :
- g) Percent impedance  
at –
- i) Normal tap % :
- ii) Lowest tap % :
- iii) Highest tap % :
- h) Position of taps (on the winding) :
- i) Make of OLTC motor :
- j) Make of digital RTCC panel :

**19. Bushings**

- a) Name of Manufacturer :



- b) Country of origin :
- c) Standard specification on which the performance data is based :
- d) **Type of bushing including Rated voltage (KV) & Current (Amps)**
- HV :
- IV :
- LV :
- Neutral :
- e) Impulse withstand (full wave) :
- HV :
- IV :
- LV :
- Neutral :
- f) 1-min. dry withstand voltage –
- HV :
- IV :
- LV :
- Neutral :
- g) Wet withstand voltage
- HV :
- IV :
- LV :
- Neutral :
- h) Puncture voltage (or flashover) Voltage whichever is minimum
- HV :
- IV :
- LV :
- Neutral :
- i) Creep age distance -



HV :  
 IV :  
 LV :  
 Neutral :

20. Neutral bushing Current Transformers -

- a) Standard specification on which :  
 Performance data is based.  
 b) Neutral CT shall be provided as per : Yes/No  
 Specification

21. **Cooling Equipment –**

- a) Number of 100 percent duty oil :  
 coolers provided  
 b) Number of oil pumps provided Running :  
 Standby :  
 c) Capacity of the oil pumps :  
 d) Power required at rated capacity for each :  
 cooler  
 e) Speed of the pump in r.p.m. :  
 f) Number, materials size and gauge thickness :  
 for each cooler  
 g) Surface area per cooler :  
 h) Pump motor – (Make)  
 - Capacity of the driving motor :  
 - No of phase :  
 - Supply voltage :  
 - Frequency :  
 - Speed :  
 - Temperature rise above 50°C ambient :  
 - Efficiency of the motor :



i) Pump motors conform to which standards :

j) No. of radiator Fans Running :

Standby :

k) Type of frame (closed or open) :

for the fan or blower motor

l) KW of the fan motor :

- Make of fan motor :

- No of phase :

- Speed of motor :

- Supply voltage :

m) The rating of the transformer with the fans out  
/off shall be stated in the following manner :

(Number of Fans cut off )

(Transformer rating)

i) One :

ii) Two :

iii) Three :

iv) All fans cut off :

v) OF rating :

vi) ON rating :

n) The period for which the transformer can be kept in operation at full load after failure of

(i) all fans :

(ii) all fans and pumps :

o) Output of the transformer upon shutting :

down the artificial cooling (expressed as  
percentage of the OFB continuous maximum  
rated output)

p) Type of control provided for ON/OFF mixed :  
cooling



q) Temperature differential range over which :  
the ON/OFF cooling in adjustable

22. **Terminal connector –**

- a) HV :
- b) IV :
- c) LV :
- d) Earth connection :

23. **Foundation details –**

- a) Rail Gauge
  - i) along minor axis :
  - ii) along major axis :

b) Foundation design shall be done as per : Yes/No  
*clause no 36 of Annexure –D of Technical specification*

24. Life of transformer (Years) min. :

25. Core-cutting/testing facility available in Works : Yes/ No  
(If no, please indicate the place of Core-cutting)

26. Transformer transportation with N<sub>2</sub> filled : Yes/ No

Including other parameter shall be maintained  
as per Transportation clause of Technical specification



- SPECIFICATION FOR 230/138/33 KV AUTO TRANSFORMER (UNLOADED TERTIARY)



- a) Tank – Sides :
- b) Tank – Bottom :
- c) Tank – Cover :
- d) Conservator plate :
- e) Radiator wall :

40. Overall shipping dimensions of the largest  
package L X W X H (mm x mm x mm) :

**Signature of the Supplier with seal**

**Designation & Date**



### **SCHEDULE – I/B contd.**

#### **II. GUARANTEED TECHNICAL PARTICULARS OF FIRE PREVENTION AND EXTINGUISHING SYSTEM BY NITROGEN (N<sub>2</sub>) INJECTION METHOD**

1. Name and address of the manufacture :
2. Address of the works :
3. Testing facility available : YES / NO
4. Make and rating of the equipment :
5. Time required for fire Extinguishing :
6. Capacity of nitrogen cylinder :
7. Capacity required for oil soak-pit :
8. Weight and dimensions of fire extinguishing cubicle :
9. Weight and dimensions of control box :
10. Power supply required :  
(220 V DC/ 230 V AC)
11. Drawing, Literature, Bill of materials and detailed scheme enclosed with the offer. :
12. Any other information the Tenderer wishes to furnish. :





13. Whether the Successful bidder is :  
agreeable to ensure that Supervision of  
Installation & Commissioning of above  
Fire prevention & Extinguishing system  
will be done by their sub-vendor as per  
requirement for which the erection  
contractor will pay the supervision  
charges separately.
14. If yes, a Certificate from the sub-vendor must  
be submitted along with the tender.

**Signature of the Supplier with seal  
Designation & Date**



## **SCHEDULE – I/B contd.**

### **III. GUARANTED TECHNICAL PARTICULARS OF NEW TRANSFORMER OIL**

Sl. No.	Property	Limits - As per TS (to be mentioned)	To be filled by the Bidder
<b>A</b>	<b>Function</b>		
1a	Viscosity at 100 °C		
1b	Viscosity at 40 °C		
1c	Viscosity at -30 °C		
2	Appearance		
3	Pour point		
4	Water content a) for bulk supply b) for delivery in drums		
5	Electric strength (breakdown voltage)		
6	Density at 20 °C		
7	Dielectric dissipation factor (tan delta) at 90 °C		
8	Negative impulse testing KVp @ 25 °C		
9	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)		
<b>B</b>	<b>Refining/Stability</b>		
1	Acidity		
2	Interfacial tension at 27 °C		
3	Total sulphur content		
4	Corrosive sulphur		
5	Presence of oxidation inhibitor		
6.	2-Furfural content		
<b>C</b>	<b>Performance</b>		



1	Oxidation stability -Total acidity -Sludge - Dielectric dissipation factor (tan delta) at 90degC		
2	Oxidation stability		
<b>D</b>	<b>Health, safety and environment (HSE)</b>		
1	Flash point		
2	PCA content		
3	PCB content		

**Signature of the Supplier with seal  
Designation & Date**



## SCHEDULE – I/ C

### SCHEDULE OF PAST EXPERIENCE

Tenderers shall fill-in this schedule in the following format for the type of equipment covered by this specification as a record of past experience.

Sl. No.	Name & Address of Purchaser/User	Equipment type Supplied	MVA rating	Voltage Ratio	Year of Manufacture	Date of Commissioning	Reference no. with date of relevant documents Such as P.O, completion certificate etc. [These documents are also required to be submitted during verification of documents]

**Note** : List of Contracts under execution is also to be furnished.

Date : .....

Place : .....

(Signature).....

(Name).....

(Designation) .....

(Common Seal) .....



## SCHEDULE: - II/A

### **SCHEDULE OF ITEMS & QUANTITIES**

**(Price not to be quoted here)**

1) Bidder's Offer No. & date:

2) Validity period of the offer:

Sl. No	Description	Qty.
1.	200 MVA, 230 KV / 138 KV / 33 KV (HV/ IV / LV) 50Hz, YNaOd1, unloaded Tertiary, Core type, 3-phase, out-door type, Oil-immersed, ONAN / ONAF / OFAF cooled Auto-transformer complete with main tank, cooler bank, OLTC suitable for voltage variation of $\pm 10\%$ in steps of 1.25%, digital RTCC Panel, Condition controlled Regenerative maintenance free Silica Gel breather for Main & OLTC Conservator, CC cabinet, terminal connectors & along with all fittings & accessories as per Specification.  The transformer shall be complete with all necessary and applicable fittings, accessories, auxiliaries and devices including but not limited to those specified in this specification.	4 (Four) Nos.
2.	Transformer oil for first filling plus 10% extra quantity (as per TS).	4 (Four) lot
3.	Complete set of equipment for Fire Prevention & Extinguishing System (FPES) by Nitrogen (N <sub>2</sub> ) Injection method as per technical specification including supply of all control & accessories, pipe, connectors required control cables, AC/DC converters etc. all complete along with supply of spare N <sub>2</sub> cylinder for above Transformer.	4 (Four) Sets
4.	Fiber Optic Temperature Sensors with its monitor, accessories, software, etc. as per technical specification for the above transformer.	4 (Four) Sets
5.	Online Dissolved Gas Analysis & Moisture content monitor with its accessories & software.	4 (Four) Sets
6.	Online Insulating Oil drying system (Cartridge type) suitable for 200 MVA, 230KV/138KV/33KV Auto-Transformer.	4 (Four) Sets
7.	<b>Type Test</b> Charges as per Specification **	
a)	Temperature rise test on one unit	1
b)	Impulse Test on one unit	1
8.	<b>Mandatory Spares</b> (for above transformer)	
a)	HV bushing as per Spec. with metal parts & gaskets	2 Nos.
b)	IV bushing as per Spec. with metal part & gaskets	2 Nos.



Sl. No	Description	Qty.
c)	LV bushing as per Spec. with metal part & gaskets	2 Nos.
d)	HV Neutral bushing (36KV) as per Spec. with metal part & gaskets	2 Nos.
e)	Buchholz relay (with alarm & trip contacts) for Main tank	2 Nos.
f)	Oil surge relay (with trip contact) for OLTC	2 Nos.
g)	Magnetic oil level gauge (with alarm / trip contact) for main conservator.	2 Nos.
h)	Magnetic oil level gauge (with alarm / trip contact) for OLTC conservator.	2 Nos.
i)	Current Transformer for HV WTI	2 Nos.
j)	Current Transformer for IV WTI	2 Nos.
k)	Current Transformer of HV-n	2 Nos.
l)	Local OTI complete with alarm & trip contacts & sensing device	2 Nos.
m)	Local WTI complete with alarm & trip contacts & sensing device	2 Nos.
n)	Remote OTI complete with alarm/trip contacts	2 Nos.
o)	Remote WTI complete with alarm/trip contacts	2 Nos.
p)	Pressure relief device	2 Nos.
q)	Oil flow indicator with flow switch	2 Nos.
r)	Remote tap position indicator	2 Nos.
s)	Cooling Fan with Motor	2 Nos.
t)	Cooling Pump with Motor	2 Nos.
u)	Set of Valves (1 no. of each size and type)	2 sets
v)	Set of starters, contactors, relays and switches for electrical control panel	2 sets
w)	Transformer Terminal Connectors (1 set for each type of rating)	2 lots
x)	Aircell (with necessary replacement kit) compatible with the Transformer	2 nos.
y)	Set of Gaskets required for complete erection of one transformer including bushings, radiators, cooling pipes etc.	2 sets
z)	Transformer Oil Sample Collection Bottle (Steel bottle fitted with inlet & outlet valve etc) – 1000 ml capacity	2 Nos.
9.	Hydraulic Jacks suitable for above transformers (1 set consisting of 4 nos.)	2 Sets



Sl. No	Description	Qty.
10.	Unloading charge per unit at site (1 unit means complete set of Transformer with all accessories, spares, tools & tackles etc.)	4 units
11.	Supervision charges per day for deputation of Engineer / Technician to supervise erection and commissioning work <b>(Optional)</b> – [N.B. General terms & conditions for supervision of erection & commissioning job shall be furnished ] Engineer / Technician day (man day)	20

**Note :**

- For type test refer to Cl. 22 of this Specification.
- Prices for Item under Sl. No.1 & 2 only, shall be variable as per PV formula indicated in the “Special Conditions of Contract”. Prices of all other items shall be FIRM.
- Prices for Optional items under Sl. No. 11 shall remain valid for delivery completion period plus one (1) year.

Signature of Tenderer’s authorized representative

Name of Tenderer’s authorized representative

Designation of Tenderer’s authorized representative

Official Seal::

Date : .....



## SCHEDULE - II/B

### **GUARANTEED TECHNICAL PARTICULARS FOR TRANSFORMER LOSSES (SHALL BE FURNISHED IN THE PRICE BID)**

Tenderers shall furnish the following GTP of the Transformers in this Schedule.

**(All losses to be indicated with IS/IEC tolerance, wherever applicable)**

1. Iron losses at 50 CPS and at
  - a) 90 percent rated voltage in KW :
  - b) 100 percent rated voltage in KW :
  - c) 110 percent rated voltage in KW :
  - d) Whether losses are FIRM :
2. Load loss (at 75°C) at 100% Load –
  - I) Between HV & IVI
    - i) Load loss at Tap No. 1 in KW :
    - ii) Load loss at Tap No. 9 in KW :
    - iii) Load loss at Tap No.17 in KW :
  - II) Between HV-LV
    - i) Load loss at Tap No. 1 in KW :
    - ii) Load loss at Tap No. 9 in KW :
    - iii) Load loss at Tap No. 17 in KW :
  - III) Load loss between IV-LV in KW :
  - IV) Whether losses are FIRM :
3. Aux./Cooler loss (Power consumption by all fans & pumps, except standby one) at rated voltage and frequency.) in KW :
4. Resistance voltage (at 75°C) at full load
  - a) HV .. % :
  - b) IV .. % :





c) LV .. % :

(All values shall be referred to rated MVA)

5. Resistance of HV winding per phase (at 75°C) in  $\Omega$  :

6. Resistance of IV winding per phase (at 75°C) in  $\Omega$  :

7. Resistance of LV winding per phase (at 75°C) in  $\Omega$  :

8. Efficiency (75°C) at unity and 0.85 pf. : Unity P.F. 0.85 P.F.

a) 100 percent load in % :

b) 75 percent load in % :

c) 50 percent load in % :

d) 25 percent load in % :

Date : ..... (Signature).....

Place : ..... (Name).....

(Designation) .....

(Common Seal) .....

XXX