14.19 **Tan δ value of OIP/RIP/RIS condenser bushing shall be 0.005 (max.) in the temperature range of 10°C to 40°C. If tan delta is measured at a temperature beyond above mentioned limit, necessary correction factor as per IEEE shall be applicable.**

15.0 Air insulated dry Cable Box for 33 kV XLPE cable (if applicable):

15.1 Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Purchaser's cable & termination and allow proper heat dissipation due to high current. Adequate measures to be applied to take-care of heat dissipation. Phase segregation shall be achieved by insulating barriers.

15.2 Thickness of cable box shall be minimum 6 mm.

15.3 Cable boxes shall have bus bars / terminal connectors of adequate size & bolt holes to receive cable lugs.

15.4 Cable boxes shall be designed to accommodate all the cable joint fittings or sealing ends required by the manufacturers of the cables, including stress/cones or other approved means for grading the voltage stress on the terminal insulation of cables operating at voltages of 33 kV between phases.

15.5 The cable boxes shall be fitted with suitable non-ferrous wiping glands with combined armour and earthing clamps. The ends of all wiping glands shall be tinned before dispatch to site. Wiping glands for single core cables shall be insulated from the box. Wiping glands insulation shall be capable of withstanding a dry high voltage test of 2 kV AC for one minute. Sufficient wiping glands shall be provided for the termination of required number of cables.

15.6 Where cable boxes are provided for three core cables, the seating sockets on the two outer phases shall preferably be inclined towards the centre to minimize bending of the cable cores. Where there is more than one core per phase, the socket block shall be so designed as to minimize bending of the cable cores.

15.7 A suitable removable gland plate of non-magnetic material shall also be provided in the cable box.

15.8 The support from base for the cable box shall be of galvanized iron.

15.9 The contractor shall provide earthing terminals on the cable box, to suit Purchaser's GI flat.

15.10 Unless otherwise approved the creepage distances and clearance to earth and between phases shall not be less than those specified below.

Highest System Voltage kV	**Insulating medium**	**Clearance between phases (mm)**	**Clearance to earth direct (mm)**	**Creepage over porcelain to similar material (mm)**	**Creepage over cable surface (mm)**
36	Air	367	237	576	576

15.11 Terminals shall be marked in a clear and permanent manner.

15.12 Cable boxes shall have removable top cover & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

15.13 The minimum length provided for terminating 33kV cable shall be 1000 mm (from cable gland plate to the cable lug) for the cable boxes. The final cable size, number & length of terminating XLPE cable shall be furnished during detailed engineering.

15.14 Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports. Cable box shall have IP-55 protection as per IS:13974.

15.15 Unless otherwise specified main cabling jointing and filling of cable boxes will be carried out by the purchaser or his Contractor as the case may be.

16.0 NEUTRAL FORMATION AND EARTHING ARRANGEMENT

The neutral of the transformer shall be brought out through bushing. The neutral terminal of transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to a convenient location at the bottom of the tank, for making connection (using bimetallic strip of adequate size) to grounding mat through separate earth pits using two (2) numbers 75 x 12 mm galvanised steel flats. Aluminium clamps & connectors of

suitable size shall be provided for connection with neutral of the transformer.

17.0 COOLING EQUIPMENT AND ITS CONTROL

17.1 Radiator based cooling for Power transformer

The transformer shall be designed with cooler system as specified in **Annexure-A** and with following provisions, as applicable.

17.1.1 The cooler shall be designed using **separately mounted radiator banks or tank mounted radiators**. Design of cooling system shall satisfy the performance requirements.

17.1.2 **In case of separately mounted radiator bank** arrangement, **radiator bank shall preferably be placed on left side of the tank while watching from HV side of the transformer**. However, **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. It shall be ensured that MOG and prismatic oil level gauge are visible from ground without any obstruction of radiator.

17.1.3 **The radiator shall be of sheet steel complying with IS 513 and minimum thickness 1.0 mm.** Each radiator bank shall be provided with the following accessories:

(a) Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
(b) Top and bottom shut off valve of at least 80mm size
(c) Drain Valve and sampling valve
(d) Top and bottom oil filling valves
(e) Air release plug at top
(f) Two grounding terminals suitable for termination of two (2) Nos. 75x12 mm galvanised steel flats.
(g) Thermometer pockets fitted with captive screw caps at cooler inlet and outlet.
(h) Lifting lugs

17.1.4 Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint (for separately/ ground mounted cooler banks) shall be provided on top and bottom cooler pipe connection.

17.1.5 **At least one number standby fan** shall be provided **with each radiator bank**.

17.1.6 **Cooling fans** shall **not be directly mounted on radiator**. The supporting frames for the cooling fans shall be fixed preferably on separate support or to the main tank in such a manner that the fan vibration does not affect the performance of the radiators and its valves. Fans shall be located so as to prevent ingress of rain water. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

17.1.7 **Two (2) nos., 100% centrifugal or axial in line oil pumps**, if 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. 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.

17.1.8 The changeover to standby oil pump in case of failure of service oil pump shall be automatic.

17.1.9 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.

17.1.10 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.

17.1.11 **Cooling fans and oil pump motors** shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall be of premium efficiency **class IE3 conforming to IS: 12615**. 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**. Motors shall have hose proof enclosure equivalent to **IP: 55** as per IS/IEC 60034-5.

17.1.12 The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

17.1.13 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.

17.1.14 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 operating range depending on types of cooling system like ONAN/ONAF/ODAF (or OFAF) or ONAN/ONAF. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

17.1.15 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.

17.1.16 Following lamp indications shall be provided in cooler control cabinet:

a) Cooler Supply failure (main)
b) Cooler supply changeover
c) Cooler Supply failure (standby)
d) Control Supply failure
e) Cooling fan supply failure for each bank
f) Cooling pump supply failure for each pump
g) Common thermal overload trip
h) Thermal overload trip for each fan/pump
i) No oil flow/reverse flow for pumps
j) Stand by fan/pump ON

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and for single phase unit connection shall be extended further to Common Marshalling Box.

17.1.17 The Cooler Control Cabinet/ Individual Marshalling Box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired up to the terminal board in the Cooler Control Cabinet/Individual Marshalling Box. All the CT secondary terminals in the Cooler Control Cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.

17.1.18 All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Common Marshalling Box (in case of 1-Ph unit) or Marshalling Box (3-Ph unit).

17.1.19 AC power for Cooler Control Circuitry shall be derived from the AC feeder. In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided.

18.0 VALVES

18.1 Type of valves shall be used for transformer as per following table. The location and size of valves for other application shall be finalised during design review. Utility may specify any other valve required for some other applications.

Sr. No.	**Description of Valve**	**Type**
1	Drain Valve	Gate
2	Filter valve	Gate
3	Sampling Valve	Globe
4	Radiator isolation valve	Butterfly
5	Buchholz relay isolation valve	Gate
6	Sudden pressure relay	Gate
7	OLTC tank equalizing valve	Gate / Needle
8	OLTC Drain cum filling valve	Gate
9	Valve for vacuum application on Tank	Gate
10	Conservator Drain valve	Gate
11	Aircell equalizing valve	Gate/Globe/Ball
12	Valve for Conservator vacuum (top)	Gate
13	Filter valve for Cooler Bank (Header)	Gate
14	Cooler Bank isolation valve	Butterfly
15	Pump Isolation valve (if applicable)	Butterfly
16	Valve for N2 injection (NIFPS) (if specified by utility)	as per OEM's recommendation.

17	Valve for NIFPS Drain (if specified by utility)	as per OEM's recommendation.
18	Valve for UHF Sensors (applicable for 400kV voltage class Transformer only)	Gate

18.2 **All valves upto and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings.** They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

18.3 Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

18.4 Each valve shall be provided with the indicator to show clearly the position (open/close) of the valve.

18.5 Gland packing/gasket material shall be of **"O" ring of nitrile rubber for all the valve's flanges**. All the flanges shall be machined.

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

18.7 **All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.**

18.8 After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to IS: 2932 and of a shade (Preferably red or yellow) distinct and different from that of main tank surface. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to IS: 2074 followed by two coats of fully glossy finishing paint.

18.9 The **oil sampling point for main tank shall have two identical valves put in series**. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

18.10 Valves or other suitable means shall be provided to fix various on line condition monitoring systems, if specified, to facilitate continuous monitoring. The location & size of the same shall be finalised during detail design review.

18.11 All hardware used shall be hot dip galvanised/stainless steel.

18.12 **Flow sensitive conservator Isolation valve (if specified by the utility)**

a) In order to restrict the supply of oil in case of a fire in transformer, flow sensitive valve shall be **provided to isolate the conservator oil from the main tank.** The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. It shall **not operate when oil pumps are switched on or off**. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

b) When the **flow from conservator** to main tank is **more than the normal operating conditions, the valve shall shut off** by itself and will have to be reset manually. It shall be provided **with valve open/close position indicator along with alarm contact indication in control room** during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset.

19.0 CABLING

19.1 All interconnecting control and power cables emanating from various parts of transformer like turret CT, MBs, Fans, pumps, Buchholz, PRD etc. shall be routed through covered cable tray or GI conduit and shall be properly dressed. All cables shall be armoured type. Un-armoured cables (if provided) in any circuitry, shall be through GI conduit and no part shall be exposed. Cable terminations shall be through stud type TB and ring type lugs. Type tested cables from approved sources shall be provided. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc. as required shall be considered included in the scope of supply. **Typical technical specification for cables is**

attached at Annexure-O. The cross section of "control cable" shall be **1.5 sq.mm (minimum)** except for **CT circuits** which should be **2.5 sq.mm (minimum)**.

20.0 TAP CHANGING EQUIPMENT

The transformer shall be provided with **On Load Tap Changing** equipment as specified in Annexure-A and shall comply with IS 8468-1/IEC 60214-1.

20.1 Main OLTC Gear Mechanism

20.1.1 The transformer as specified in **Annexure-A** shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load. The OLTC shall conform to IS 8468/IEC 60214 (Part 1& 2). The requirement of voltage regulation (on HV), location (physical and electrical) of tap winding, range of voltage variation, no. of steps etc. shall be as given in **Annexure-A**.

20.1.2 The **OLTC** shall be of **high speed transition resistor type**. OLTC shall be motor operated suitable for local as well as remote operation.

20.1.3 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 auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment. The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer and the chamber shall be designed to withstand the vacuum. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.

20.1.4 The voltage class, maximum tapping current, step voltage of OLTC shall have adequate design margin for safe & reliable service life of both OLTC and transformer. OLTC shall have long contact life, quick & easy to disassemble diverter switch inserts, simple to adjust & control and easy to replace diverter's contacts etc.

20.1.5 Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

20.1.6 The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve, accessible from ground, shall be provided to take sample of oil from the OLTC chamber. It shall also be **fitted with an oil surge relay** which shall be connected **between OLTC oil chamber and OLTC conservator tank**. **Provision of a suitable device like tie-in-resistor has to be made, wherever required, to limit the recovery voltage to a safe value.** The use of tie-in-resistor (if used) shall be clearly marked in rating and diagram plate of the transformer. The whole of the driving mechanism shall be of robust design and capable of giving satisfactory service without undue maintenance.

20.1.7 Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

20.1.8 As an alternative to conventional OLTC with traditional diverter switch immersed in oil (where arcing takes place in oil), vacuum type OLTC (where arcing takes place in a hermetically sealed vacuum interrupter) may also be provided. However, provisions as specified above shall be followed as far as applicable.

20.2 Local OLTC Control Cabinet (Drive Mechanism Box)

20.2.1 OLTC shall be suitable for manual (handle operated) and electrical (motor operated) operation. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.

20.2.2 The power supply for on-load tap changer motors mounted in Drive mechanism shall be suitable for operation on 230V 1-phase or 3-phase 415V, 50Hz external power supply. The control circuit shall operate at 110 V single phase to be supplied from a transformer having a ratio of either 415/55-0-55V or 230/55-0-55V with the centre point earthed through a removable link mounted in the marshalling box

20.2.3 **OLTC's Local control cabinet shall be mounted on the tank** in accessible position. The cranking device/handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level (preferably at a height less than1800mm). The mechanism shall be complete with the following:

(a) Mechanical tap position indicator, which shall be clearly visible near the transformer.

(b) A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting.

(c) Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.

(d) The manual control, considered as back up to the motor operated on load tap changer control, shall be interlocked with the motor to block motor start-up during manual operation.

(e) The manual operating mechanism shall be labelled to show the direction of operation for raising the voltage and vice-versa.

(f) An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change, until the mechanism comes to rest and resets circuits for a fresh position.

20.2.4 For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is in use. It shall not be possible for any two controls to be in operation at the same time. Transfer of source in the event of failure of operating AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit.

20.2.5 The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the following:

(a) A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor

(b) Emergency Push Button to stop OLTC operation

(c) Cubicle light with door switch

(d) Anti-condensation metal clad heaters to prevent condensation of moisture

(e) Padlocking arrangement (or locking arrangement suitable for long term operation) for hinged door of cabinet

(f) All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.

(g) The cabinet shall be tested at least IP 55 protection class.

20.2.6 In case auxiliary power supply requirement for OLTC Drive Mechanism (DM) Box is different than station auxiliary AC supply, then all necessary converters shall be provided.

20.2.7 Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations/ repeat commands.

20.2.8 Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

20.2.9 OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position input to digital RTCC/relevant BCU (as applicable)/SCADA system. The tap position indicator shall also be provided in control room.

20.2.10 '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 cut-off/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.

20.2.11 The following minimum LED indications shall be provided in DM box:

(a) INCOMPLETE STEP
(b) OLTC motor overload protection operated
(c) Supply to DM Motor fail
(d) OLTC IN PROGRESS
(e) Local / Remote Selector switch positions of DM
(f) OLTC upper/lower limits reached
(g) 415V Main AC supply ON
(h) 415V Standby AC supply ON

20.2.12 The following minimum contacts shall be available in DM Box and these contacts shall be further wired to digital RTCC panel/relevant BCU (as applicable):

(a) INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
(b) OLTC motor overload protection
(c) Supply to DM Motor fail
(d) OLTC IN PROGRESS
(e) Local/Remote Selector switch position
(f) OLTC upper/lower limits reached

20.2.13 All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked/ labelled for the purpose of identification. Both ends of all the wires (control & power) connected to Drive Mechanism Box must be provided with proper ferrule nos. for tracing and maintenance.

20.2.14 A permanently legible lubrication chart and control circuit drawing shall be fitted within the OLTC local control cabinet.

20.3 Remote Control & Monitoring of OLTC

For substations/ pooling stations having Substation Automation System, Control & monitoring of OLTC shall be carried out through Substation Automation System. Following functionalities specified for digital RTCC shall be realised in soft logic in Substation Automation System. All hardwire signals from/to OLTC shall be wired to Bay Control Units (BCUs) provided by the owner/contractor, as applicable.

20.3.1 The digital RTCC relay shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features to remotely control and monitor OLTC.

20.3.2 Each digital RTCC relay shall be used to control one unit of transformer. No. of relays including spare relay, if any, shall be specified by the utility as per requirement.

20.3.3 All digital relays can be housed in the BCU panel.

20.3.4 **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.

20.3.5 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.

20.3.6 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.

20.3.7 The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA/ SAS, with a facility to have the possibility of additional set points command from SCADA/ SAS.

20.3.8 **In Manual Mode**: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.

20.3.9 **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

20.3.10 **Master/Follower/Independent/Off mode**

Master/Follower/Independent/Off mode is required in Digital RTCC relay for parallel/group operation of transformers. Master-follower scheme implies that controlled decision shall be taken by the Master and control actions (Raise/Lower tap position) shall be executed simultaneously by Master & Follower units. Same logic needs to be implemented in digital RTCC relays.

Master Position: If the digital RTCC relay is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the digital RTCC relay is in Follower position, control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected.

Suitable interlock arrangement shall be provided to avoid unwanted/inconsistent operation of OLTC of the transformer

20.3.11 **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the Transformers.

20.3.12 Digital RTCC relays shall communicate with SCADA using IS/IEC 61850 through fibre optic port to monitor, parameterise and control the OLTC. Any software required for this purpose shall be supplied. 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.

20.3.13 Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. Suitable communication hardware shall be provided to communicate up to distance of 1 km between digital RTCC relays. Scope shall also include communication cables between digital RTCC relays. Cables as required for parallel operation of OLTCs of all transformers (including existing transformers wherever required) from Digital RTCC relays shall be considered included in the scope.

20.3.14 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.

20.3.15 The relays shall ensure completion of lowering/raising of the OLTC tap, once the command is issued from the relay. "Step-by-Step" operation shall be ensured so that only one tap change from each tap changing

pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

20.3.16 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.

20.3.17 The relay shall have facility to monitor operating hours of tap changer and register the tap changer statistics. In the statistics mode, the relay shall display the no. of tap changing operations occurred on each tap.

20.3.18 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.

20.3.19 Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs:

(a) INCOMPLETE STEP alarm
(b) OLTC motor overload protection alarm
(c) Supply to DM Motor fail alarm
(d) OLTC IN PROGRESS alarm
(e) Local / Remote Selector switch positions in DM Box
(f) OLTC upper/lower limits reached alarm
(g) OLTC Tap position indications for transformer units
(h) 415V, AC Mail Supply Fail.
(i) 415V, AC Standby Supply Fail

20.3.20 In case of parallel operation, OLTC out of step alarm shall be generated in the digital RTCC relay for discrepancy in the tap positions.

21.0 SCADA INTEGRATION (if applicable)

All the online monitoring equipment i.e. Optical Temperature Sensors & Measuring Unit, Online Dissolved Gas (Multi-gas) and Moisture Analyzer, On-line insulating oil drying system (Cartridge type) etc. provided for individual transformer, shall be IS/IEC 61850 compliant (either directly or through a Gateway). These monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IS/IEC 61850. This Ethernet switch shall be provided in IMB. The switch shall be powered by redundant DC supply (as per available Station DC supply). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C. All required power &

control cables including optical cable, patch chord (if any) upto IMB, all the cables from RTCC to DM and any special cable between IMB to switchyard panel room/control room shall be in the scope.

However, fiber optic cable, power cable, control cables, as applicable, between IMB to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IS/IEC-61850 compliant equipment with Substation Automation System may be a part of sub-station contract.

Cooling and OLTC of transformers shall also be monitored and controlled from SCADA. List of Signal exchange between Transformer and SCADA may be mutually agreed between the owner and manufacturer. Owner/contractor, as applicable, shall ensure provision of adequate number of redundant Bay control Units (BCUs).

22.0 CONSTRUCTIONAL FEATURES OF COOLER CONTROL CABINET/ INDIVIDUAL MARSHALLING BOX/ OUTDOOR CUBICLE/DIGITAL RTCC PANEL

22.1 Each transformer unit shall be provided with local OCTC/OLTC Drive Mechanism Box (DMB), Cooler Control Cabinet/Individual Marshalling Box, and **Digital RTCC panel** (as applicable).

22.2 Individual **Marshalling Box (IMB) and Cooler Control Box** shall be **tank mounted** or ground mounted. All cabinets except CMB & Digital RTCC panel shall be tank mounted. All separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application. The gland plate shall be at least 450 mm above ground level.

22.3 The Cooler Control Cabinet (CCC)/Individual Marshalling Box (IMB) , and **all other outdoor cubicles (except OLTC Drive Mechanism box)** shall be made **of stainless steel sheet of minimum Grade SS 304 and of minimum thickness of 1.6 mm. Digital RTCC panel** shall be made of **CRCA sheet of minimum thickness of 2.0 mm** and shall be painted suitably as per **Annexure–K**.

22.4 The degree of protection shall be **IP: 55 for outdoor and IP: 43 for indoor** in accordance with IS/IEC: 60947.

22.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For

Control cubicle/Marshalling Boxes etc. which are **outdoor type**, all the **sealing gaskets shall be of EPDM rubber or any other (approved) material** of better quality, whereas for all **indoor** control cabinets/Digital RTCC panel, the **sealing gaskets shall be of neoprene rubber or any other (approved) material** of better quality. The gaskets shall be tested in accordance with approved quality plan and IS: 3400.

22.6 All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the Marshalling Box. All the CT secondary terminals in the Marshalling Box shall have provision for shorting to avoid CT open circuit while it is not in use.

22.7 Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. Thermostat controlled space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

23.0 AUXILIARY POWER SUPPLY FOR OLTC, COOLER CONTROL AND POWER CIRCUIT

23.1 **Two auxiliary power supplies of 415 volt, three phase four (4) wire** shall be provided by the Purchaser **at Cooler Control Cabinet / Marshalling Box**. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the Cooler Control Cabinet/Marshalling Box.

23.2 For each circuit, suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply distribution scheme including distribution to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor Box etc. (as applicable), shall be provided in cooler control cabinet/ Marshalling Box.

23.3 Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from marshalling box to all accessories is in the scope of the manufacturer/contractor (as applicable). Further any special cable (if required) from MB to Owner's Control Panels/Digital RTCC panels is also in the scope of the manufacturer/contractor (as applicable).

23.4 All relays and operating devices shall operate correctly at any voltage within the limits specified below:

Normal Voltage	Variation in voltage	Frequency (in Hz)	Phase/Wire	Neutral connection
415 V	±10%	50±5%	3 Phase 4Wire	Solidly earthed
240 V	±10%	50±5%	1 Phase 2 Wire	Solidly earthed
220 V	190 V to 240 V	DC	Isolated 2 wire system	--
110 V	95 V to 120 V	DC	Isolated 2 wire system	--
48 V	--	DC	2 wire system (+) earthed	--

Combine variation of voltage and frequency shall be limited to ±10%.

23.5 Design features of the transfer scheme shall include the following:

a) Provision for the selection of one of the feeder as normal source and other as standby.
b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
c) Indication to be provided at cooler control cabinet/Individual Marshalling Box for failure of normal source and for transfer to standby source and also for failure to transfer.
d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.
e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

24.0 BUSHING CURRENT TRANSFORMER

24.1 Current transformers shall comply with IS 16227 (Part 1 & 2)/IEC 61869 (part 1 & 2).

24.2 Current transformers shall be suitable for withstanding vapor phase drying treatments at 135 deg C and for continuous operation in hot oil at 105 deg C. All material used in CT construction shall be compatible with oil throughout its service life without deteriorating properties of oil.

24.3 Current transformers secondary winding conductor insulation shall be Polyvinyl Alcohol (PVA) as per IEC 60317-1 or polyamide as per IEC 60317-3 and CT secondary leads shall have cross section area of

minimum 4 sq.mm. CT secondary shall be capable of withstanding 2kV rms for 1 min.

24.4 Polarities (P1 & P2) shall be permanently marked on Current transformer.

24.5 Current transformer should be provided with nameplate made of Bakelite material and pasted with glue & wrapped with fiberglass tape to avoid plate from becoming losses after vapor phase drying.

24.6 It shall be possible to remove the turret mounted current transformers from the Transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

24.7 Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

24.8 Indicative technical parameters of Bushing CTs are provided at **Annexure–B. These parameters are tentative and liable to change within reasonable limits. Purchaser's approval shall be obtained before proceeding with the design of bushing current transformers.** The CTs used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

24.9 Secondary resistance and magnetising current characteristics of PX class (protection) CT of same rating shall be similar. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

25.0 TOOLS & TACKLES

Each transformer shall be supplied with a full kit of tools & spanners of required sizes; bushing handling & lifting tools with nylon rope/belt, with a rack for holding them; required numbers of hydraulic jacks for lifting the transformers, and for changing the plane of rotation of wheels. All spanners shall be single ended and case hardened. Tirfors with wire rope and slings with grippers etc. for hauling the transformer to the plinth are to be supplied along with each transformer. Utility may add/remove tools as per their requirement.

26.0 FITTINGS & ACCESSORIES

The following fittings & accessories shall be provided with each transformer covered in this specification. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the equipment are deemed to be included.

(a) Conservator for main tank with aircell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge, prismatic oil level gauge and dehydrating silica gel filter breather with flexible connection pipes to be used during replacement of any silica gel breather.

(b) Conservator for OLTC with drain valve, oil surge relay, filling hole with cap, magnetic oil level gauge, prismatic oil level gauge and dehydrating breather with flexible connection pipes to be used during replacement of any silica gel breather.

(c) Pressure relief devices with special shroud to direct the hot oil

(d) Sudden pressure relief relay (if desired by utility)

(e) Buchholz relay (double float, reed type) with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm/trip contacts.

(f) Conservator air cell rupture detection relay

(g) Air release plug

(h) Inspection openings and covers

(i) Bushing of each type with metal parts and gaskets to suit the termination arrangement

(j) Winding & Oil temperature indicators (local & remote)

(k) Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs

(l) Protected type alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator as applicable (mercury should not be used)

(m) Rating and diagram plates (in English & Hindi or as specified by the utility) on transformers and auxiliary apparatus

(n) Roller Assembly (flanged bi-directional wheels)

(o) One complete set of all metal blanking plates & covers

(p) On load tap changing gear DM Box, individual marshalling box, Cooler control cabinet, and Digital RTCC Panel as applicable

(q) Cooling equipment including fans & pumps (as applicable)

(r) Bushing current transformers, Neutral CT (if applicable)

(s) Oil/water flow indicators (if applicable)

(t) Terminal marking plates

(u) Valves schedule plate

(v) Bottom oil sampling valve, Drain valves (provided to drain each section of pipe work independently), Filter valves at top and bottom with threaded male adaptors, Shut off valves on the pipe connection between radiator bank & the main tank, Shut off valves on both sides of Buchholz relay, Sampling gas collectors for Buchholz relay at accessible height, Valves for Radiators, Valve for vacuum application, Valves for cable box (if applicable), Valve for on line DGA (if applicable), valves for Drying out system (if applicable), Flow sensitive Conservator Isolation Valve (if applicable), Gate Valve (4 Nos. of min. 50 NB) for UHF sensors for PD Measurements (applicable for 400kV voltage class Transformer only), valves for firefighting system (as applicable) and other valves as specified in the specification.

(w) Ladder (suitably placed to avoid fouling with bushing or piping) to climb up to the transformer tank cover with suitable locking arrangement to prevent climbing during charged condition. Additional ladder for conservator in case it is not tank mounted.

(x) Suitable platform for safe access of flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from transformer top.

(y) Haulage/ lifting lugs

(z) Suitable terminal connectors on bushings

(aa) Brass/tinned copper grounding bar supported from the tank by using porcelain insulator and flexible conductor for earthing of neutral, HV & LV terminals as per specification

(bb) Oil Sampling Bottle & Oil Syringe (if specified)

27.0 INSPECTION AND TESTING

The manufacturer shall draw up and carry out a comprehensive inspection and testing programme in the form of detailed quality plan duly approved by Purchaser for necessary implementation during manufacture of the equipment. Details regarding Quality Assurance Programme covering quality assurance, inspection and testing have been covered in **Chapter-3: Quality Assurance Programme.**

28.0 DRAWINGS/DOCUMENTS/CALCULATIONS

The list of drawing/documents/calculations to be submitted by the manufacturer is given in **Annexure-H.**

All utilities are advised to digitalize drawing approval process to speed up drawings & MQP submittals, comments, re-submittals and final approval.

29.0 RATING & DIAGRAM PLATE

The transformer shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the appropriate items indicated below. The entries on the plate shall be in English in indelibly marked.

Information to be provided on the plate:

Manufacturer's name, country and city where the transformer was assembled					
MVA Rating, Voltage ratio, Type of transformer (for example 315MVA 400/220/33kV Auto Transformer)					
Type of Cooling			Applicable Standard		
Rated Power at different cooling			Rated frequency	Hz	

HV	MVA	--/--/--	Number of phases		
LV (for single LV winding) / (LV1 & LV2) for two LV windings	MVA		% Impedance / Ohmic Impedance		
Rated Voltage			(a) HV-LV or HV-LV1 HV-LV2 (as applicable)		
HV	kV		Min. tap	%	
Tertiary winding Voltage (if applicable)	kV		Principal Tap	%	
LV(for single LV winding) / (LV1 & LV2) for two LV windings	kV		Max. Tap	%	
Rated Current			(b) LV1-LV2 (if applicable)		
HV	A		(c)		
LV (for single LV winding)	A		Vector Group		
(LV1 & LV2) for two LV windings	A		Core mass	Kg	
Rated Thermal Short Circuit withstand capability Current and Duration	kA (sec)		Copper Mass		
Basic Insulation Level (Lightening Impulse/Switching Impulse/Power Frequency Withstand Voltage)			(a) HV	Kg	

HV	kVp/ kVp/ kVrms		(b) LV (for single LV winding) / LV1+ LV2 (for two LV windings)	Kg	
Tertiary winding	kVp/ kVp/ kVrms		(c) Tertiary	Kg	
LV (for single LV winding) / LV1 & LV2 (for two LV windings)	kVp/ kVp/ kVrms		(d) Regulating	Kg	
Neutral	kVp/ kVp/ kVrms		Core & Coil Mass	Kg	
Guaranteed Temperature rise over ambient temperature of 50 Deg. C			Transportation Mass	Kg	
(a) Top Oil	^{0}C		Tank & Fitting mass		
(b) Winding	^{0}C		Type & total mass of insulating oil	Kg	
Vacuum withstand Capability of the tank	mm of Hg		Total mass	Kg	
OLTC make and rating (current & Voltage class)			Quantity of oil in OLTC	Ltrs	
Noise level at rated voltage and at principal tap	dB		Transformer oil Quantity	Ltrs	
Tan delta of winding			Paint Shade		

Moisture content	ppm		No load loss at rated voltage & frequency	KW	
Manufacturer's Serial number			Load loss at rated current & frequency (at 75^0C) for HV & LV (or LV1+LV2, as applicable) winding	KW	
Year of manufacture					
Work Order No.			Auxiliary loss at rated voltage & frequency	KW	
Purchaser's Order No. & Date					
OGA Drg. No.					
Vector Group Diagram					
Winding Connection diagram (Connection between all windings including tap windings, ratings of built-in current transformers, etc. shall be presented on the diagram)					
Table giving details of Tap Changer like tap position Nos. and corresponding tapping voltage, tapping current & connection between terminals for different tap positions etc.					
Details of Current Transformers (e.g. Bushing CTs, CT for WTI) installed in transformer like the location, core Nos., ratio(s), accuracy class, rated output (VA burden), knee point voltage, magnetizing current, maximum CT secondary resistance, terminal marking and application of the current transformer					
Warning: "Main conservator is fitted with an air cell"					
Tie-in-resistor has been used in OLTC (if applicable)					
Purchaser's Name					

When a transformer is intended for installation at high altitude, the altitude, power rating and temperature rise at that altitude shall be indicated on the nameplate.

Plates with identification and characteristics of auxiliary equipment according to standards for such components (bushings, tap-changers,