glands, lugs, cable tags/ numbers etc as required shall be considered included in the scope of supply.

16. Tap Changing Equipment

Each transformer shall be provided with Off load tap / On Load Tap changing equipment as specified elsewhere.

16.1. Off load tap Changer equipment (if applicable)

The off load / Off Circuit tap changer (OCTC) equipment shall be handle operated with a locking arrangement along with tap position indicator. The external handle shall be situated in an unobstructed position. The contacts are positively self-locating in each tapping position without constraint from the operating mechanism. The rating of the contacts shall be suitable to carry maximum current of the transformer. For three phase transformer the tap change switch shall simultaneous switch the similar taps on the three phases. A warning plate indicating that OCTC shall be operated only when the transformer is de-energised, shall be fitted.

16.2. ON Load Tap Changing (OLTC) Equipment

16.2.1. Main OLTC Gear Mechanism

16.2.1.1. Each single / three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load.

16.2.1.2. OLTC shall be motor operated suitable for local as well as remote operation. 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. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.

16.2.1.3. 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.

16.2.1.4. The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve of minimum size, 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.

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

16.2.2. Local OLTC Control Cabinet (Drive Mechanism Box)

Each transformer unit of OLTC gear shall have following features:

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

16.2.2.2. 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. The mechanism shall be complete with the following:

- Mechanical tap position indicator which shall be clearly visible from near the transformer.
- 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.
- Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.
- 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.
- The manual operating mechanism shall be labelled to show the direction of operation for raising the voltage and vice-versa.
- An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

16.2.2.3. 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 one AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit.

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

i. A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor
ii. Emergency Push Button to stop OLTC operation
iii. Cubicle light with door switch
iv. provided with anti-condensation metal clad heaters to prevent condensation of moisture
v. Padlocking arrangement for hinged door of cabinet
vi. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
vii. The cabinet shall be tested at least IP 55 protection class.

16.2.2.5. All relays and operating devices shall operate correctly at any voltage within the limits specified in Section - GTR. In case auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

16.2.2.6. 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.

16.2.2.7. 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.

16.2.2.8. 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 indication in CMB (for single phase unit) and input to Digital RTCC/SCADA system.

16.2.2.9. '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 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 DM Box. In remote mode electrical commands from CMB/ Digital RTCC/SCADA etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

16.2.2.10. Following minimum contacts shall be available in DM Box, which shall be wired to CMB for single phase unit. Further these contacts shall be wired to Digital RTCC panel:

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

16.2.2.11. 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.

16.2.2.12. A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

16.2.3. **OLTC Control from Common Marshalling Box (CMB)**

16.2.3.1. It shall be possible to monitor, control/operate, the OLTC of all the three 1-phase transformers of a transformer bank from Common Marshalling Box. The control and monitoring terminations of a spare transformer unit shall be brought to CMB. The necessary switching arrangement through male-female plug-in TB assembly shall be provided for replacing spare unit with any one of the faulty phase unit for monitoring & control from CMB.

16.2.3.2. 'Independent-combined-remote selector switch, raise/lower switch and emergency stop Push Button shall be provided in the common marshalling box for OLTC control.

16.2.3.3. When the selector switch is in **independent** position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.

16.2.3.4. In **'combined position'**, raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.

16.2.3.5. In **'remote position'** control of OLTC shall be possible from Digital RTCC/SCADA etc.

16.2.3.6. From CMB, the operation of OLTC shall be for 3-phases of transformer units without producing phase displacement. Independent operation of each single phase transformer from CMB/ Digital RTCC/SCADA will be prevented.

16.2.3.7. Following minimum **LED indications** shall be provided in CMB:

a. INCOMPLETE STEP
b. OLTC motor overload protection
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

Following **contacts** shall be wired to TBs in CMB for further wiring to C & R Panels.

i. 415V Main AC supply Fail
j. 415V Standby AC supply Fail

Following **contacts** shall be wired to TBs in CMB for further wiring to digital RTCC Panel:

a. INCOMPLETE STEP
b. OLTC motor overload protection
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. 'Independent-combined-remote' selector switch positions of CMB

Further, OLTC Tap position Digital indications for all three 1-Ph Transformer units either separately or through selector switch shall be provided in CMB. The same shall also be wired to Digital RTCC Panel to display tap positions for all three 1-ph unit separately.

16.3. **Digital RTCC Panel**

16.3.1. The digital RTCC panel shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as **Digital RTCC relay**) to remotely control and monitor OLTC. The relay shall be offered from the manufacturer who has already supplied Digital RTCC relay, which is in operation for at-least 2 years for transformer OLTC application.

16.3.2. For new substation, the contractor shall provide Digital RTCC panel consisting of 4 Nos. Digital RTCC relays which shall be used to control 4 banks of transformers (i.e. 12 Nos. 1-Phase units or 4 Nos. 3-Phase units), unless otherwise specified elsewhere. Further, one spare Digital RTCC relay shall also be provided in the same panel.

For existing substations, the requirement of digital RTCC panel and relays are specified in Section-Project/BPS. However, bidders are advised to get clarified about the availability of existing RTCC schemes /Digital RTCC relays to finalise matching digital RTCC relays requirements. The Digital RTCC relays envisaged for existing transformers shall be integrated for parallel operations. All required cables for the same shall be included in the scope.

16.3.3. Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-built large 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 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.

All Digital RTCC Relays shall be of same make for smooth integration of these relays for parallel operations of all transformers in the substation.

16.3.4. The digital RTCC Panel shall be provided with digital RTCC relay having Raise/Lower push buttons, Manual/ Automatic mode selection features, Master / Follower/ Independent/ Off mode selection features and emergency stop Push Button for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.

16.3.5. **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.

16.3.6. **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.

16.3.7. **Master / Follower/ Independent/ Off mode**

Master Position: If the selector switch 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 selector switch 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

16.3.8. **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the complete bank of three 1-phase transformers / 3-Phase Transformers. Individual 1-phase OLTC operation shall not be possible from the remote control panel.

16.3.9. Digital RTCC relays shall communicate with SCADA using IEC 61850 protocols to monitor, parameterise & 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. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA, with a facility to have the possibility of additional set points command from SCADA.

Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. IEC- 61850 GOOSE messaging between Digital RTCC relays for OLTC parallel operation is not permitted. Suitable communication hardware shall be provided to communicate up to distance of 1km 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 of bidder.

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

16.3.11. The relays shall ensure positive 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.

16.3.12. 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. 'Independent-combined-remote selector switch positions of CMB

16.3.13. In case of parallel operation or 1-Phase Transformer unit banks OLTC out of step alarm shall be generated in the digital RTCC panel for discrepancy in the tap positions.

17. Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ Common Marshalling Box and Digital RTCC Panel

17.1. Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet /individual marshalling box. Digital RTCC panel and common marshalling (for a bank of three 1-phase units) shall be provided.

17.2. The cooler control cabinet, Individual Marshalling Box, Common Marshalling Box, shall be made of stainless steel sheet of at least 1.6 mm thick. Digital RTCC panel shall be CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure –F**.

17.3. The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS: 13947/IEC: 60947.

17.4. 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 better approved quality, whereas for all indoor control cabinets / Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

17.5. 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.

17.6. The size of Common marshalling box shall not be less than 1600mm (front) X 650mm (depth) X 1800mm (height). All the cabinets except common marshalling box & Digital RTCC shall be tank mounted. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application.

18. 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 transformer are deemed to be included.

a. Conservator for main tank with air cell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with low & high level alarm contacts and dehydrating breather

b. Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and dehydrating breather

c. Pressure relief devices

d. Sudden pressure relief relay (**for 400kV Transformer only**)

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. Air release plug

g. Inspection openings and covers

h. Bushing with metal parts and gaskets to suit the termination arrangement

i. Winding & Oil temperature indicators for local and remote mounting

j. Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs

k. Protected type mercury or alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator

l. Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve

m. Rating and diagram plates (in Hindi & English) on transformers and auxiliary apparatus

n. On load tap changing gear, OLTC DM Box, Off Circuit Tap Changer (OCTC) individual marshalling box / Cooler control cabinet, Common Marshalling Box, Fibre optic sensor box and Digital RTCC Panel as applicable

o. Cooling equipment

p. Bushing current transformers

q. Oil flow indicator (if applicable)

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

s. Terminal marking plates

t. Valves schedule plate

u. Ladder to climb up to the Transformer tank cover with suitable locking arrangement to prevent climbing during charged condition

v. 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.

w. Haulage lugs

x. On line insulating oil drying system

y. Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment (if specified in BPS)

z. On line dissolved Hydrogen and Moisture Measuring Equipment (if specified in BPS)

aa. Fibre optic sensor based temperature measuring system (for 400kV Transformer only)

bb. Flow sensitive conservator Isolation valve

cc. Flanged bi-directional wheels

dd. Nitrogen Injection Type Fire Prevention & Extinguishing System (if specified in BPS) as per **Annexure – K**

ee. Managed Ethernet switch, LIU patch cords etc. shall be provided in CMB/MB. All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

19. Current Transformer

19.1. Current transformers shall comply with IEC-60044-1.

19.2. 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.

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

19.4. For 1-Phase Transformer, one number single phase current transformer (outdoor) for earth fault protection shall be provided for each bank of transformer and shall be located in the neutral conductor connecting common neutral point with earth.

19.5. Technical Parameters of Bushing CTs and Neutral CTs are enclosed at **Annexure – H.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Purchaser's approval before proceeding with the design of bushing current transformers.

19.6. Secondary resistance and magnetising current characteristics of TPS class (protection) (as per IEC) CT of same rating shall be identical. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

20. Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment

Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment (if specified in BPS) along with all required accessories shall be provided with each transformer for measurement & analysis of dissolved gases and moisture in the oil. The detailed technical specification is enclosed at **Annexure-L**.

21. On Line Dissolved Hydrogen and Moisture Measuring Equipment

Online Dissolved Hydrogen and Moisture Measuring Equipment (if specified in BPS) along with all required accessories shall be provided with each transformer for

monitoring of dissolved Hydrogen and moisture in the oil. The detailed technical is enclosed at **Annexure-M**.

22. On-line insulating oil drying system (Cartridge type)

On-line insulating oil drying system (Cartridge type) along with all required accessories shall be provided with each Transformer. The detailed technical specification is enclosed at **Annexure-N**.

23. Oil Storage Tank

23.1. Oil storage tank shall be of capacity as specified in BPS along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS: 803 or other internationally acceptable standards. Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100°C.

23.2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

23.3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

23.4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horse power to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

23.5. The following accessories shall also form part of supply along with each Oil storage tank:

i) Four numbers of 50NB suitable rubber hoses for transformer oil application up to temperature of 100°C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

ii) Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

iii) One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be

provided with at-least 8 meter cable so as to suitably place the Vacuum gauge at ground level.

23.6. The painting of oil storage tank and its control panel shall be as per technical specification.

23.7. The tank shall contain a self-mounted centrifugal oil pump with inlet and outlet valves, with couplers suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

24. Oil Sampling Bottle

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from transformers for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre.Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.

An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

25. Oil Syringe

If specified in BPS, the glass syringe of capacity 50ml (approx) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC-60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient finger tip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused.

26. Hand Tools

One set of hand tools **(if specified in BPS)** 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, 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 per Substation for which cost shall be deemed included.

27. Test Kit

- BDV Kit (if specified in BPS)as per **Annexure-J** of specification
- Portable DGA Kit (if specified in BPS)as per **Annexure-J** of specification

28. Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Purchaser for necessary implementation.

28.1. **Inspection**

28.1.1. **Tank and Conservator**

a. Certification of chemical analysis and material tests of plates
b. Check for flatness
c. Electrical interconnection of top and bottom by braided tinned copper flexible
d. Welder's qualification and weld procedure
e. Testing of electrodes for quality of base materials and coatings
f. Inspection of major weld preparation
g. Crack detection of major strength weld seams by dye penetration test
h. Measurement of film thickness of:
   i. Oil insoluble varnish
   ii. Zinc chromate paint
   iii. Finished coat
i. Check correct dimensions between wheels, demonstrate turning of wheels through 90 degree and further dimensional check.
j. Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to Non Destructive Testing.
k. Leakage test of the conservator
l. Certification of all test results

28.1.2. **Core**

a. Sample testing of core materials for checking specific loss, bend properties, magnetisation characteristics and thickness
b. Check on the quality of varnish if used on the stampings:
   i) Measurement of thickness and hardness of varnish on stampings
   ii) Solvent resistance test to check that varnish does not react in hot oil
   iii) Check overall quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface
c. Check on the amount of burrs
d. Bow check on stampings
e. Check for the overlapping of stampings. Corners of the sheet are to be part.
f. Visual and dimensional check during assembly stage

g. Check for inter-laminar insulation between core sectors before and after pressing
h. Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps
i. High voltage test (2 kV for one minute) between core and Yoke clamps, Yoke clamps to tank and Core to Tank
j. Certification of all test results

28.1.3. **Insulation Material**

a. Sample check for physical properties of materials
b. Check for dielectric strength
c. Visual and dimensional checks
d. Check for the reaction of hot oil on insulating materials
e. Dimension stability test at high temperature for insulating material
f. Tracking resistance test on insulating material
g. Certification of all test results

28.1.4. **Winding**

a. Sample check on winding conductor for mechanical properties and electrical conductivity
b. Visual and dimensional checks on conductor for scratches, dent marks etc.
c. Sample check on insulating paper for pH value, bursting strength and electric strength
d. Check for the reaction of hot oil on insulating paper
e. Check for the bonding of the insulating paper with conductor
f. Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust
g. Check for absence of short circuit between parallel strands
h. Check for brazed joints wherever applicable
i. Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready
j. Conductor enamel test for checking of cracks, leakage and pin holes
k. Conductor flexibility test
l. Heat shrink test for enamelled wire
m. Certification of all test results

28.1.5. **Checks Before Drying Process**

a. Check condition of insulation on the conductor and between the windings.
b. Check insulation distance between high voltage connections, cables and earth and other live parts
c. Check insulating distances between low voltage connections and earth and other parts
d. Insulation of core shall be tested at 2 kV/minute between core and Yoke clamps, Yoke clamps to tank and Core to Tank
e. Check for proper cleanliness and absence of dust etc.
f. Certification of all test results

28.1.6. **Checks During Drying Process**

a. Measurement and recording of temperature, vacuum and drying time during drying process
b. Check for completeness of drying by periodic monitoring of dryness
c. Certification of all test results

28.1.7. **Assembled Transformer**

a. Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.
b. Test to check effective shielding of the tank
c. Jacking test of Transformer in oil-filled condition (excluding separately mounted cooler bank)
d. Dye penetration test shall be carried out after the jacking test

28.1.8. **Bought Out Items**

The makes of all major bought out items shall be subject to Purchaser's approval for the following components:

a) Buchholz Relay
b) Axles and wheels
c) Winding temperature indicators for local and remote mounting
d) Oil temperature indicators
e) Bushings
f) Bushing current transformers
g) Cooler control cabinet/ Individual Marshalling box and common marshalling box as applicable
h) Cooling equipment
i) Oil pumps
j) Fans/Air Blowers
k) Tap change gear
l) Pressure relief device

The above list is not exhaustive and the Contractor shall also include other bought-out items in his programme.

28.2. **Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.

The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.

The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated in "**Annexure-B".**

All tests shall be done in line with IEC: 60076 and the test procedures as mentioned in "**Annexure-B".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

28.3. **Type Tests on fittings:**

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the Section – GTR:

1) Bushing (Type Test as per IEC:60137 including Snap back/Seismic test for 400 kV and above voltage class bushing)

2) OLTC (Test as per IEC:60214 and IP-55 test on driving mechanism box)

3) Buchholz relay (Type Test as per IS: 3637 and IP-55 Test on terminal box)

4) Cooler Control cabinet, Individual Marshalling & common marshalling box (IP-55 test)

5) Pressure Relief device Test

   The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test above. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.

   The terminal box / boxes of PRD should conform to degree of protection of IS 13947/Equivalent IEC standard.

6) Sudden Pressure Relay Test

7) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.

8) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016

9) OTI & WTI

10) Oil pump

11) Cooling fan and motor assembly

28.4. **Pre-Shipment Checks at Manufacturer's Works**

28.4.1. Check for inter-changeability of components of similar transformers for mounting dimensions.

28.4.2. Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

28.4.3. Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

28.4.4. Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

28.5. **Inspection and Testing at Site**

The Contractor shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the Purchaser is given below. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Purchaser. Testing of oil sample at site shall be carried out as per specification.

28.6. **Receipt and Storage Checks**

28.6.1. Check and record condition of each package, visible parts of the transformer etc. for any damage.

28.6.2. Check and record the gas pressure in the transformer tank as well as in the gas cylinder.

28.6.3. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

28.6.4. Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

28.7. **Installation Checks**

28.7.1. Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc.

28.7.2. Check the direction of rotation of fans and pumps and Check the bearing lubrication.

28.7.3. Check whole assembly for tightness, general appearance etc.

28.7.4. Oil leakage test

28.7.5. Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

28.7.6. Leakage check on bushing before erection.

28.7.7. Measure and record the dew point of gas in the main tank before assembly.

28.8. **Commissioning Checks**

28.8.1. Check the colour of silicagel in silicagel breather.

28.8.2. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

28.8.3. Check the bushing for conformity of connection to the lines etc.,

28.8.4. Check for correct operation of all protection devices and alarms/trip :

i. Buchholz relay
ii. Excessive winding temperature
iii. Excessive oil temperature

iv. Low oil flow
v. Low oil level indication
vi. Fan and pump failure protection

28.8.5. Check for the adequate protection on the electric circuit supplying the accessories.

28.8.6. Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

i) Control wiring
ii) Cooling system motor and control
iii) Main windings
iv) Tap changer motor and control

28.8.7. Check for cleanliness of the transformer and the surroundings

28.8.8. Phase out and vector group test

28.8.9. Ratio test on all taps

28.8.10. Magnetising current test

28.8.11. Capacitance and Tan delta measurement of winding and bushing

28.8.12. Frequency response analysis (FRA). FRA equipment shall be arranged by purchaser.

28.8.13. DGA of oil just before commissioning and after 24 hours energisation at site.

28.8.14. Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

28.8.15. Continuously observe the transformer operation at no load for at least 24hours.

28.8.16. Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures enclosed at **Annexure – D** and forward to Purchaser for future record.

1.0 Technical Particulars / Parameters of Transformers (400/220/33 kV, 3-Phase Auto Transformer)

Clause No.	Description	Unit	Technical Parameters	
1.1	Rated Capacity			
	HV	MVA	500	167
	IV	MVA	500	167
	LV (Tertiary) : Active + Reactive loading	MVA	1/3 RD of rated capacity of HV winding	
1.2	Voltage ratio (Line to Line)		400/220/33	
1.3	Single / Three Phase Design		3 (THREE)	1 (SINGLE)
1.4	Applicable Standard		IEC 60076	
1.5	Frequency	Hz	50	50
1.6	Cooling & Percentage Rating at different cooling		ONAN/ONAF/(OFAF or ODAF) : 60% / 80%/100% OR ONAN/ONAF1/ONAF2: 60% / 80%/100% OR OFAF (with 5 x 25% unit cooler)	
1.7	Type of Transformer		Constant Ohmic impedance type (Refer note 1)	
1.8	Impedance at 75 Deg C			
	HV - IV			
	Max. Voltage tap	%	10.3	
	Principal tap	%	12.5	
	Min. Voltage tap	%	15.4	
	HV - LV			
	Principal tap (minimum)	%	60.0	
	IV - LV			
	Principal tap (minimum)	%	45.0	
1.9	Tolerance on Impedance (HV-IV)	%	As per IEC	
1.10	Service		Outdoor	
1.11	Duty		Continuous	
1.12	Overload Capacity		IEC-60076-7	
1.13	Temperature rise over 50deg C ambient Temp			
i)	Top oil measured by thermometer	^{o}C	50	
ii)	Average winding measured by resistance method	^{o}C	55	
1.14	Windings			
i)	System Fault level			
	HV	kA	63	
	IV	kA	40	
	LV	kA	25	
ii)	Lightning Impulse withstand Voltage			
	HV	kV_p	1300	
	IV	kV_p	950	

	LV	kV_p	250
	Neutral	kV_p	95
iii)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	570
	IV	kV_{rms}	395
	LV	kV_{rms}	95
	Neutral	kV_{rms}	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vii)	Tertiary Connection		Ungrounded Delta
viii)	Tan delta of winding	%	< 0.5
1.15	Vector Group (3 –ph) (unless specified differently elsewhere)		YNaOd11
1.16	Tap Changer		OLTC
i)	Tap Range & No. of steps		± 10% of HV variation in the step of 1.25%, 16 steps
ii)	Location of Tap changer		On the 220 kV side of the series winding
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow
1.17	Bushing		
i)	Rated voltage		
	HV	kV	420
	IV	kV	245
	LV	kV	52
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	2000
	LV	A	3150
	Neutral	A	2000
iii)	Lightning Impulse withstand Voltage		
	HV	kV_p	1425
	IV	kV_p	1050
	LV	kV_p	250
	Neutral	kV_p	170
iv)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
	IV	kV_p	850

Annexure -B

Test Plan

No.	Test	U_m ≤ 170kV	U_m > 170kV
1.	Measurement of winding resistance	Routine	Routine
2.	Voltage ratio measurement	Routine	Routine
3.	Polarity test	Routine	Routine
4.	No-load loss and current measurement	Routine	Routine
5.	Magnetic balance test (for three phase Transformer only)	Routine	Routine
6.	Impedance and load loss measurement	Routine	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine	Routine
8.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Routine	Routine
9.	Chopped wave lightning impulse test for the line terminals (LIC)	Type	Routine
10.	Full wave lightning impulse test for the line terminals (LI)	Routine	-
11.	Measurement of transferred surge on LV (Tertiary) as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Type	Type
12.	Switching impulse test for the line terminal (SI)	Type	Routine
13.	Line terminal AC withstand voltage test (LTAC)	Routine	Type
14.	Induced voltage withstand test (IVW)	Routine	-
15.	Applied voltage test (AV)	Routine	Routine
16.	Induced voltage test with PD measurement (IVPD)	Routine	Routine
17.	On-load tap changer test(Ten complete cycle before LV test)	Routine	Routine
18.	Gas-in-oil analysis	Routine	Routine
19.	Core assembly dielectric and earthing continuity test	Routine	Routine
20	Oil leakage test on transformer tank	Routine	Routine
21.	Appearance, construction and dimension check	Routine	Routine
22.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine	Routine
23.	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	Routine	Routine
24.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine	Routine
25.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine	Routine
26	Tank vacuum test	Routine	Routine
27.	Tank pressure test	Routine	Routine
28.	Lightning impulse test for the neutral terminals (LIN)	Type	Type
29.	Temperature rise test	Type	Type
30.	Measurement of Zero seq. reactance (for three phase Transformer only)	Type	Type
31.	Measurement of harmonic level in no load current	Type	Type
32.	Measurement of acoustic noise level	Type	Type
33.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	Type	Type
34.	Dynamic Short circuit withstand test (If specified in BPS)	Type	Type

Annexure - C

Test Procedures

1. Core assembly dielectric and earthing continuity test

After assembly each core shall be tested for 1 minute at 2000 Volts between all yoke clamps, side plates and structural steel work (core to frame, frame to tank & core to tank).

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2 kV (DC) for 1 minute. Insulation resistance shall be minimum 1 GΩ for all cases mentioned above.

2. Short term heat run test (Not Applicable for unit on which temperature rise test is performed)

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short term heat run test to confirm the performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core.

DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 cigre 1984 SC12-13 paper by Dam, Felber, Preiniger et al.

Short term heat run test may be carried out with the following sequence:

- Heat run test with pumps running but oil not through coolers.
- Raise temperature to 5 deg less than the value measured during temperature rise test.
- Stop power input and pumps for 6 minutes and observe cooling down trend
- Restart pumps and observe increased cooling trend due to forced oil flow

3. Temp. Rise Test as per IEC: 60076

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567.

The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) for the Top oil of the transformer.

3-Winding Loss = HV (Max MVA) + IV(Max MVA) + LV (Max MVA).

The Contractor before carrying out such test shall submit detailed calculations showing losses on various taps and for the three types of ratings of the transformer and shall recommend the combination that results in highest temperature rise for the test.

The Temperature rise type test results shall serve as a "finger print" for the units to be tested only with short term heat run test.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

i. Test conditions for temperature rise test:

- This test shall be generally carried out in accordance with IEC 60076-2
- For each cooling combination with cooler bank, tests shall be done on the maximum current tap for a minimum of 12 hours for ONAN/ONAF and 24 hours for ODAF or OFAF or ONAF2 with saturated temperature for at least 4 hours while the appropriate power and current for core and load losses are supplied.
- The total testing time, including ONAN heating up period, steady period and winding resistance measurements is expected to be about 48 hours.
- DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

ii. Test records:

Full details of the test arrangements, procedures and conditions shall be furnished with the test certificates and shall include at least the following.

iii. General:

- Purchaser's order number and transformer site designation.
- Manufacturer's name and transformer serial number.
- Rating of transformer
- MVA
- Voltages and tapping range
- Number of phases
- Frequency
- Rated currents for each winding
- Vector Group
- Cooling Type
- Measured no-load losses and load losses at 75° C.
- Altitude of test bay.
- Designation of terminals supplied and terminals strapped.

iv. Top oil temperature rise test:

A log of the following quantities taken at a minimum of 30 minute intervals:

- time
- Voltage between phases
- Current in each phase and total power
- Power in each phase and total power
- Ambient temperature
- Top oil temperature
- Cooler inlet and outlet oil temperatures
- Hot spot temperatures (make use of probes) (if applicable)
- Colour photographs of the four sides and top of the transformer together with the corresponding series of thermal images (colour) during starting and end of the test. It is also recommended to take thermal images 4 more times to take care of any unforeseen situation.

v. Winding temperature rise test

- Record the 'cold' resistance of each winding and the simultaneous top oil and ambient air temperatures, together with the time required for the effect to disappear.
- Record the thermal time constant of the winding.
- Log the half-hourly readings of the quantities as for the top oil temperature rise test.
- Provide a table of readings, after shut-down of power, giving the following information ;

    a) Time after shut- down:
    b) Time increment:
    c) Winding resistance: At least 20 minutes reading
    d) Resistance increment:

- Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.
- Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors (fibre optic) placed at various locations shall also be recorded.

4. Tank Tests

i. Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure equal to normal head of oil plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

ii. **Vacuum Test**

All transformer tanks shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of flat plate (in mm)	**Permanent deflection (in mm)**
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

iii. **Pressure Test**

All transformer tanks, its radiator, conservator and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

5. Dynamic short circuit withstand test shall be carried out as per IEC 60076-5. Dynamic short circuit test shall be carried out in HV-IV combination at nominal & extreme tap positions. For LV winding, dynamic short circuit shall be carried out either on HV-LV or IV-LV combination, whichever draws higher short circuit current as per calculation. Type tests shall be carried out before short circuit test. Following shall also be conducted before and after Short Circuit test:

i) Dissolved gas analysis
ii) Frequency response analysis
iii) All routine tests

Detail test procedure shall be submitted by contractor & shall be approved before short circuit test.

6. Routine test on bushings shall be done as per IEC 60137

Annexure –D

Reference Drawings

The list of drawings indicated below forms a part of this specification.

Sr. No	Drawing Description	Drawing No.
i)	Standard Foundation Drawing (315MVA, 400/220/33kV Auto Transformer)	0000-000-T-E-A-003
ii)	Standard dimensions for RIP Condenser bushings (Lower portion)	0000-T-E-A-001 R02
iii)	Typical arrangement of transformer with regulating winding at the end of the series winding.	000S3-YE4-014
iv)	Conceptual drawing for optical fiber sensor	C/ENGG/STD/ optical fiber sensor/AT-SR, REV 0
v)	Pre-Commissioning Procedures and formats for switchyard equipment	D-2-01-03-01-04, issued on 01-04-2013 or latest.
vi)	Conceptual drawing for showing power and control cable connection for operation with spare unit	C/ENGG/TR/SPARE/CABLE/STD REV01
vii)	Conceptual drawing for showing power and control cable for operation of 3-Ph Transformer	C/ENGG/STD/CABLE/TR REV0

Annexure–E

Design Review Document

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics upto $1.7U_m$
3.	Inrush-current characteristics while charging from HV & IV respectively.
4.	Winding and tapping design
5.	Short-circuit withstand capability including thermal stress for min. 2 Sec.
6.	Thermal design including review of localised potentially hot area.
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Tap changers
15.	Protective devices
16.	Fans, pumps and radiators
17.	Sensors and protective devices– its location, fitment, securing and level of redundancy
18.	Oil and oil preservation system
19.	Corrosion protection
20.	Electrical and physical Interfaces with substation
21.	Earthing (Internal & External)
22.	Processing and assembly
23.	Testing capabilities
24.	Inspection and test plan
25.	Transport and storage
26.	Sensitivity of design to specified parameters
27.	Acoustic Noise
28.	Spares, inter-changeability and standardization
29.	Maintainability
30.	PRD and SPR (number & locations)
31.	Conservator capacity calculation
32.	Winding Clamping arrangement details with provisions for taking it "in or out of tank"
33.	Conductor insulation paper details
34.	Location of Optical temperature sensors
35.	The design of all current connections
36.	Location & size of the Valves

Annexure – F

Painting Procedure

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank& DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethan e (PU) (Minimum 50µm)	Minimum 155µm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	Minimum 30µm	Glossy white for paint
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy base Zinc primer (30-40µm)	PU paint (Minimum 50µm)	Minimum 100µm	Matching shade of tank/ different shade aestheticall y matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40µm (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	--	--
Digital RTCC Panel	Seven tank process as per IS:3618 & IS:6005	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat or POWDER coated	Minimum 80µm / for powder coated minimum 100µm	RAL 7035 shade for exterior and Glossy white for interior
Control cabinet / Marshalling Box - No painting is required.						

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

Annexure – G

Unused inhibited Insulating Oil Parameters

Sl. No.	Property	Test Method	Limits
A	**Function**		
1a.	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm2/s
1b.	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)12 mm2/s
1c.	Viscosity at -30degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)1800 mm2/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 or ASTM D97	(Max.)- 40degC
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.)50 kV(new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	ISO 3675 or ISO 12185 or ASTM D 4052	0.820 - 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90 deg C	IEC 60247 or IEC 61620 Or ASTM D924	(Max) 0.0025
8.	Negative impulse testing KVp @ 25 deg 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 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
B	**Refining/Stability**		
1.	Acidity	IEC 62021-1 or ASTM D974	(Max) 0.01 mg KOH/g
2.	Interfacial tension at 27degC	ISO 6295 or ASTM D971	(Min) 0.04 N/m
3.	Total sulphur content	BS 2000 part 373 or ISO 14596 or ASTM D 2622 or ISO 20847	0.05 % (Max.) (before oxidation test)
4.	Corrosive sulphur	IEC 62535	Non-Corrosive on copper and paper
		ASTM D1275B	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.)
C	**Performance**		
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.)
D	**Health, safety and environment (HSE)**		
1.	Flash point	ISO 2719	(Min.)135deg C
2.	PCA content	BS 2000 Part 346	Max 3%
3.	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)
E	**Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:**		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	**Each lot of the oil shall be tested prior to filling in main tank at site for the following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		More than 0.04 N/m
G	**After filtration & settling and prior to energisation at site oil shall be tested for following:**		
1	Break Down voltage (BDV)	IS: 1866 / IEC 60422	70 kV (min.)
2	Moisture content at hot condition		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*Oxidation Stability	Test method as per IEC 61125 method C, Test duration: 500hour for inhibited oil	
	a) Acidity		0.3 (mg KOH /g) (max.)
	b) Sludge		0.05 % (max.)
	c) Tan delta at 90 °C		0.05 (max.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)
	* Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of POWERGRID.		

2.0 Current Transformer Parameters (On each phase) for 3-ph 500MVA and 1-ph, 167 MVA, 400/220/33 kV Transformers

Description	Current Transformer Parameters (Transformer)		
	HV Side	IV Side	Neutral Side
(a) Ratio			
CORE 1	1600/1	1600/1	1600/1
CORE 2	1000/1	1600/1	
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	1600V, TPS	1600V, TPS	1600V, TPS
CORE 2	0.2 Class 30VA ISF≤5	0.2 Class 30VA ISF ≤ 5	
(c) Maximum CT Secondary Resistance			
CORE 1	4.0 Ohm	4.0 Ohm	4.0 Ohm
CORE 2	-	-	
(d) Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	25 mA	25 mA	25 mA
CORE 2	-	-	

NOTE:

i) For TPS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively. Class (for the relevant protection and duties) as per IEC 60185.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

ANNEXURE - I

1.1 KV GRADE POWER & CONTROL CABLES

1.1 All Power & Control cables shall be supplied from Employer's approved vendors.

1.2 Separate cables shall be used for AC & DC.

1.2 Separate cables shall be used for DC1 & DC2.

1.3 At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All aluminium used in the cables shall be of H2 grade.

1.5 The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

1.10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

1.11 Repaired cables shall not be accepted.

1.12 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.13 **PVC Power Cables**

1.13.1 The PVC (70°C) insulated 1100V grade power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS: 5831 for all cables.

1.14 **PVC Control Cables**

1.14.1 The 1100V grade control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the Employer to be black.

1.14.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS : 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES)

Sr. No	Description	Parameters	
1a	Cable Sizes	1 C x 630	3½ C x 300
b	Manufacturer's type designation	A2XWaY	A2XWY
2	Applicable standard	IS: 7098/PT-I/1988 & its referred specifications	
3	Rated Voltage(volts)	1100 V Grade	
4	Type & Category	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both	
6	Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70 °C of PVC Cables[For information only]	732	410
7	Rating factors applicable to the current ratings for various conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 sec duration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA	45kA	45kA
b	Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above	250°C	
9	Conductor		
a	Material	Stranded Aluminium as per Class 2 of IS : 8130	
b	Grade	H 2 (Electrolytic grade)	
c	Cross Section area (Sq.mm.)	630	300/150
d	Number of wires(No.) minimum	53	30/15
e	Form of Conductor	Stranded and compacted circular	Stranded compacted circular/sector shaped
f	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in	
10			
11	Insulation		
a	Composition of insulation	Extruded XLPE as per IS-7098 Part(1)	
b	Nominal thickness of insulation(mm)	2.8	1.8/1.4
c	Minimum thickness of insulation	2.42	1.52/1.16
12	Inner Sheath		
a	Material	Extruded PVC type ST-2 as per IS-5831-84	
b	Calculated diameter over the laid up cores,(mm)	NA	52
c	Thickness of Sheath (minimum)mm	NA	0.6
d	Method of extrusion	NA	Pressure/Vacuum extrusion
13	Armour		
a	Type and material of armour	Al wire [H4 grade]	Gal. Steel wire
b	Direction of armouring	Left hand	
c	Calculated diameter of cable over inner sheath (under armour), mm	33.9	53.2
d	Nominal diameter of round armour wire (minimum)	2	2.5
e	Guaranteed Short circuit capacity of the armour for 0.12 sec at room temperature.	45kA	45kA
f	DC resistance at 20 °C (Ω/Km)	$	0.577
14	Outer Sheath	ST-2 & FR	ST-2 & FR
A	Material (PVC Type)	38.3	59.50

B	Calculated diameter under the sheath	1.72	2.36
C	Min. thickness of sheath(mm)	Min 29.0	Min 29.0
D	Guaranteed value of minimum oxygen index of outer sheath at 27 °C	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	colour of sheath	$	$
15a	Nominal Overall diameter of cable	+2/-2 mm	
b	Tolerance on overall diameter (mm)	shall conform to IS 10418 and technical specification	
16	Cable Drums	1000/500	1000/500
a	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)		
b	Non-standard drum lengths	Maximum one(1) non-standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)	
17	Whether progressive sequential marking on outer sheath provided at1 meter interval 18	Yes	
18	Identification of cores		
a	colour of cores	As per IS 7098 Part(1)	
b	Numbering	NA	
19	Whether Cables offered are ISI marked	Yes	
20	Whether Cables offered are suitable for laying as per IS 1255	Yes	

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC POWER CABLES

SN	Description	Parameters					
1a	Cable Sizes	1 c x 150	3.5 cx 70	3.5 cx 35	4 c x 16	4c x 6	2 c x 6
1b	Manufacturer's type designation	AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards					
3	Rated Voltage(volts)	1100 V grade					
4	Type & Category	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both					
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	202	105	70	41	24	28
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67					
8	Short circuit Capacity						
a)	Short Circuit Amp. (rms)KA for 1 sec duration	11.2	5.22	2.61	1.19	0.448	0.448
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C					
9	Conductor						
a)	Material	STRANDED ALUMINIUM					
b)	Grade	H 2 (Electrolytic grade)					
c)	Cross Section area (Sq.mm.)	150	M-70 N-35	M-35 N-16	16	6	6
d)	Number of wires(No.)	as per Table 2 of IS 8130					
e)	Form of Conductor	Non-compacted Stranded circular	shaped conductor	shaped conductor	shaped conductor	Non-compacted Stranded circular	Non-compacted Stranded circular
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layer					
10	Conductor resistance (DC) at 20 oC per km-maximum	0.206	0.443/0 .868	0.868/ 1.91	1.91	4.61	4.61
11	Insulation						
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84					
b)	Nominal thickness of insulation(mm)	2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0
c)	Minimum thickness of insulation	1.79	1.16/0.9 8	0.98/0. 8	0.8	0.8	0.8
12	Inner Sheath						
a)	Material	Extruded PVC type ST-I as per IS-5831-84					
b)	Calculated diameter over the laid up cores,(mm)	N.A	27.6	20.4	15.7	11.6	9.6
c)	Thickness of Sheath (minimum) mm	N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/88					
a)	a) Type and material of armour	Al. Wire[H4 grade]	Gal.steel strip	Gal.steel strip	Gal.steel strip	Gal.steel wire	Gal.steel wire
b)	b) Direction of armouring	left hand					
c)	c) Calculated diameter of cable	18	28.4	21	16.3	12.2	10.2

	over inner sheath (under armour), mm						
d)	d) Nominal diameter of round armour wire/strip	1.6 4	0.8 4	0.8 4	0.8	1.4	1.4
e)	e) Number of armour wires/strips	Armouring shall be as close as practicable					
f)	f) Short circuit capacity of the armour along for 1 sec-for info only	K x A√t (K Amp)(where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 for steel					
g)	g) DC resistance at 20 oC (Ω/Km)	0.44	2.57	3.38 4	3.99	3.76	4.4
14	Outer Sheath						
a)	a) Material (PVC Type)	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
b)	b) Calculated diameter under the sheath	21.2	30.1	22.6	17.9	15	13
c)	c) Min. thickness of sheath(mm)	1.4	1.56	1.4	1.4	1.4	1.24
d)	d) Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	e) Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	f) colour of sheath	Black	Black	Black	Black	Black	Black
15a)	a) Overall diameter of cable	$					
b)	b) Tolerance on overall diameter (mm)	+2/-2 mm					
16	Cable Drums	shall conform to IS 10418 and technical specification					
a)	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
b)	b) Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)					
17	Whether progressive sequential marking on outer sheath provided	Yes					
18	Identification of cores						
a)	a) colour of cores	Red	R,Y,Bl & Bk	R,Y,Bl& Bk	R,Y,Bl & Bk	R,Y,Bl & Bk	Red & Bk
b)	b) Numbering	N.A	N.A	N.A	N.A	N.A	N.A
19	Whether Cables offered are ISI marked	YES					
20	Whether Cables offered are suitable for laying as per IS 1255	YES					

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

SN	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c cx 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed or unearthed system	for both							
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp. (rms)KA for 1 sec duration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C							
9	Conductor								
a)	Material	Plain annealed High Conductivity stranded Copper (as per IS 8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 oC per km-maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84							
b)	Nominal thickness of	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

	insulation(mm)								
c)	Minimum thickness of insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath								
a)	Material	Extruded PVC type ST-I as per IS-5831-84							
b)	Calculated diameter over the laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							
a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter of cable over inner sheath (under armour), mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22.7
d)	Nominal diameter of round armour wire/strip	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity of the armour along for 1 sec-for info only	0.05 x A$\sqrt{t}$ (K Amp)(where A = total area of armour in mm2 & t = time in seconds)							
g)	DC resistance at 20 oC (Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
c)	Min.thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
d)	Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500							

b)	Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)							
17	Whether progressive sequential marking on outer sheath provided								
18	Identification of cores	Yes							
a)	colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offered are ISI marked	YES							
20	Whether Cables offered are suitable for laying as per IS 1255	YES							

$'- As per manufacturer design data

ANNEXURE - L

Online Dissolved Gas (Multi-gas) and Moisture Analyser

1.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories shall be provided with each transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

1.2. The equipment shall detect, measure and analyse the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
O_2 (Optional)	500 – 25,000 ppm
H_2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

1.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

1.4. Equipment shall havefacility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

1.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

1.6. Online DGA shall be installed out door on transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV 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 Steelenclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility.The Equipment must carry a minimum of two (2) years manufacturer's Warranty.

1.7. The equipment shall 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.

1.8. The equipment shall be able to measure gas concentration and when downloaded should immediately compare it with user selected alarm & caution level for immediate display. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval.

1.9. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

1.10. The technical feature of the equipment shall be as under:

Accuracy	$\pm$ 10%
Repeatability	$\pm$3% to 10% depending upon gases
Oil temperature range	- 20^0 C to + 120^0 C
External Temp. Range	- 20^0 C to + 55^0 C (External temp range of 55^0 C is important and should not be compromise due to Indian ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB&IEC 61850 compliant

1.11. Software for fault indication and fault diagnostics shall include following:
Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending

Fault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

1.12. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

ANNEXURE - N

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 on line insulating oil drying system of adequate rating with proven field performance.

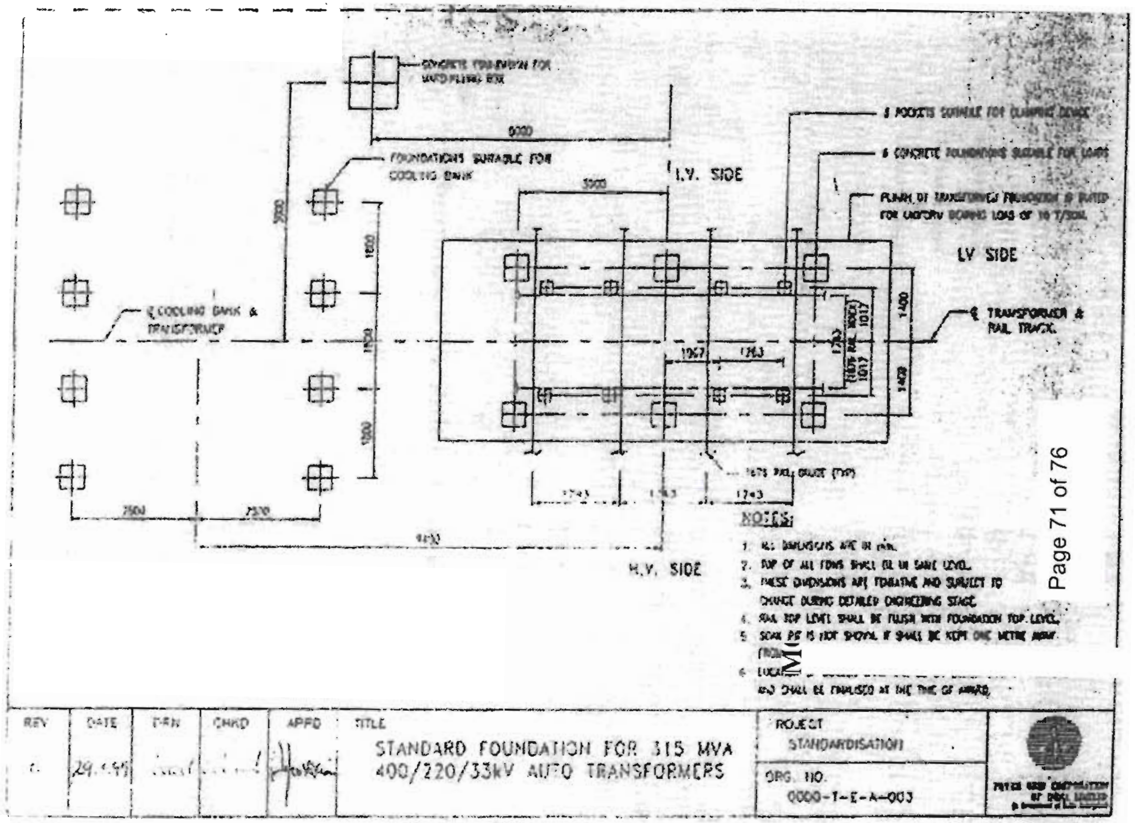
Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided to support and protect the piping arrangement.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. This on line 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.

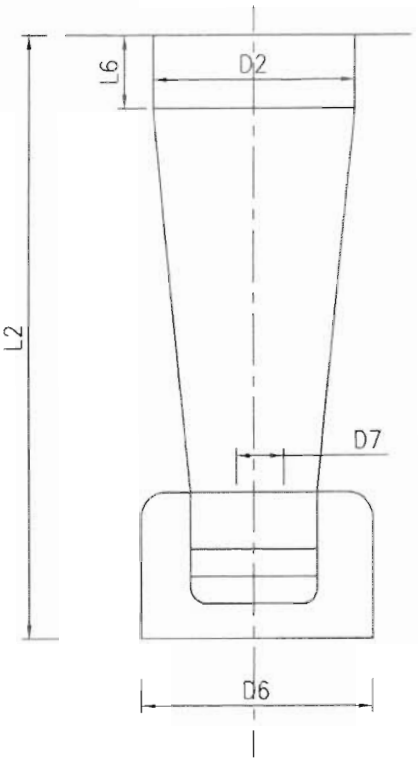
ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

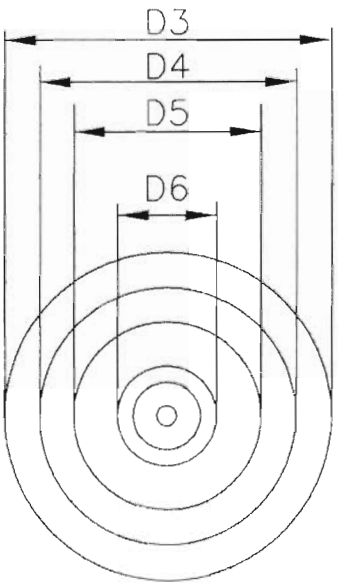
The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.



L.V. SIDE
LV SIDE
H.V. SIDE
NOTES:
TOP OF ALL FDNS SHALL BE IN SAME LEVEL.
RAIL TOP LEVEL SHALL BE FLUSH WITH FOUNDATION TOP LEVEL.
REV
DATE
DRN
CHKD
APPD
TITLE
STANDARD FOUNDATION FOR 315 MVA
400/220/33kV AUTO TRANSFORMERS
PROJECT
STANDARDISATION
DRG. NO.
0000-T-E-A-003



VOLTAGE RATING KV	420	245	145	72.5	52
BIL (kV_p)	1425	1050	650	325	250
CREEPAGE (MM) (Min.)	10500	6125	3625	1810	1300
CURRENT RATING (A) (Min.)	800 / 1250	1250 / 2000	800	800	3150
L2±5 (FOR DIFF. VALUES OF L6)	1640	1130 / 1230	600#/800	695	475
L6 (MIN.)	400	300	100#/300	300	100
D2 (Max.)	350	270	165	115	165
D3±2	720	450	335	225	335
D4±1	660	400	290	185	290
D5xN	24x12	20x12	15x12	15x6	15x12
D6 (MAX)	350	270	165	115	115
D7 (Min)	60	48 / –	38	—	—

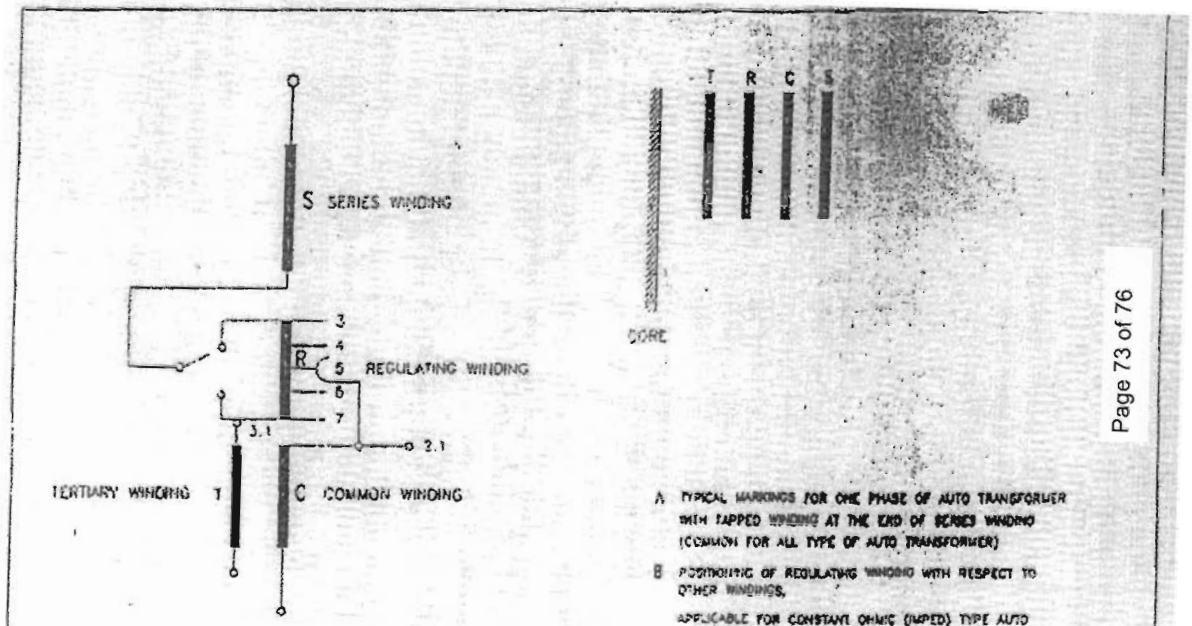


NOTE:

1. ALL DIMENSIONS ARE IN MM
2. NO POSITIVE TOL. WHERE MAX. DIMENSION SPECIFIED AND NO NEG. TOL. WHERE MIN. DIMENSION IS SPECIFIED

APPLICABLE FOR SHUNT REACTOR

PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG NO
			STD. DIMN. FOR RIP CONDENSER BUSHINGS (LOWER PORTION)	000-T-E-A-001-R02

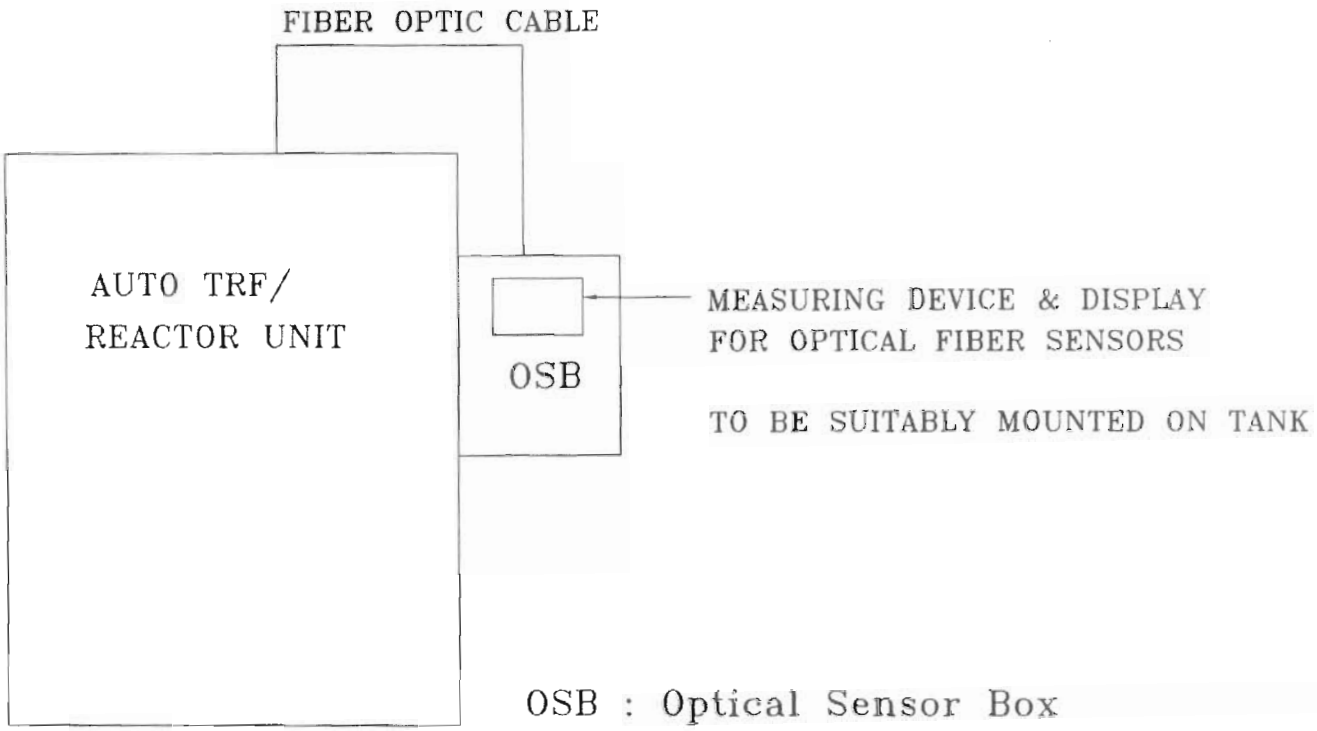


A TYPICAL MARKINGS FOR ONE PHASE OF AUTO TRANSFORMER WITH TAPPED WINDING AT THE END OF SERIES WINDING (COMMON FOR ALL TYPE OF AUTO TRANSFORMER)

B POSITIONING OF REGULATING WINDING WITH RESPECT TO OTHER WINDINGS.

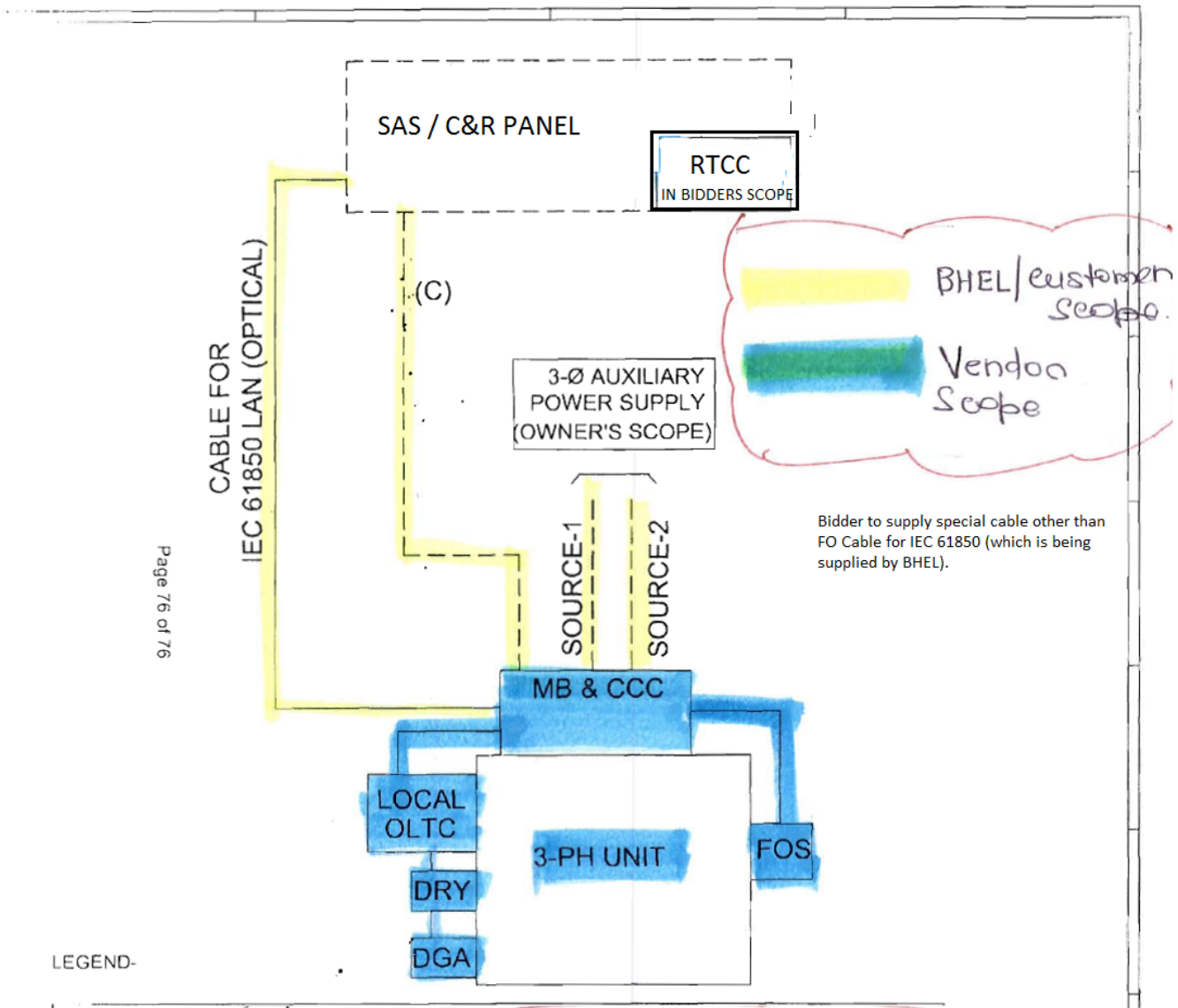
APPLICABLE FOR CONSTANT OHMIC (IMPED) TYPE AUTO TRANSFORMERS ONLY.

REV	DATE	DRN	CHKD	APPD	TITLE	PROJECT
C	28.4.99				TYPICAL ARRANGEMENT FOR ONE PHASE OF AUTO TRANSFORMERS WITH REGULATING WINDING AT THE END OF SERIES WINDING	STANDARDISATION
						DRG. NO. 0083-TE4-014



OSB : Optical Sensor Box

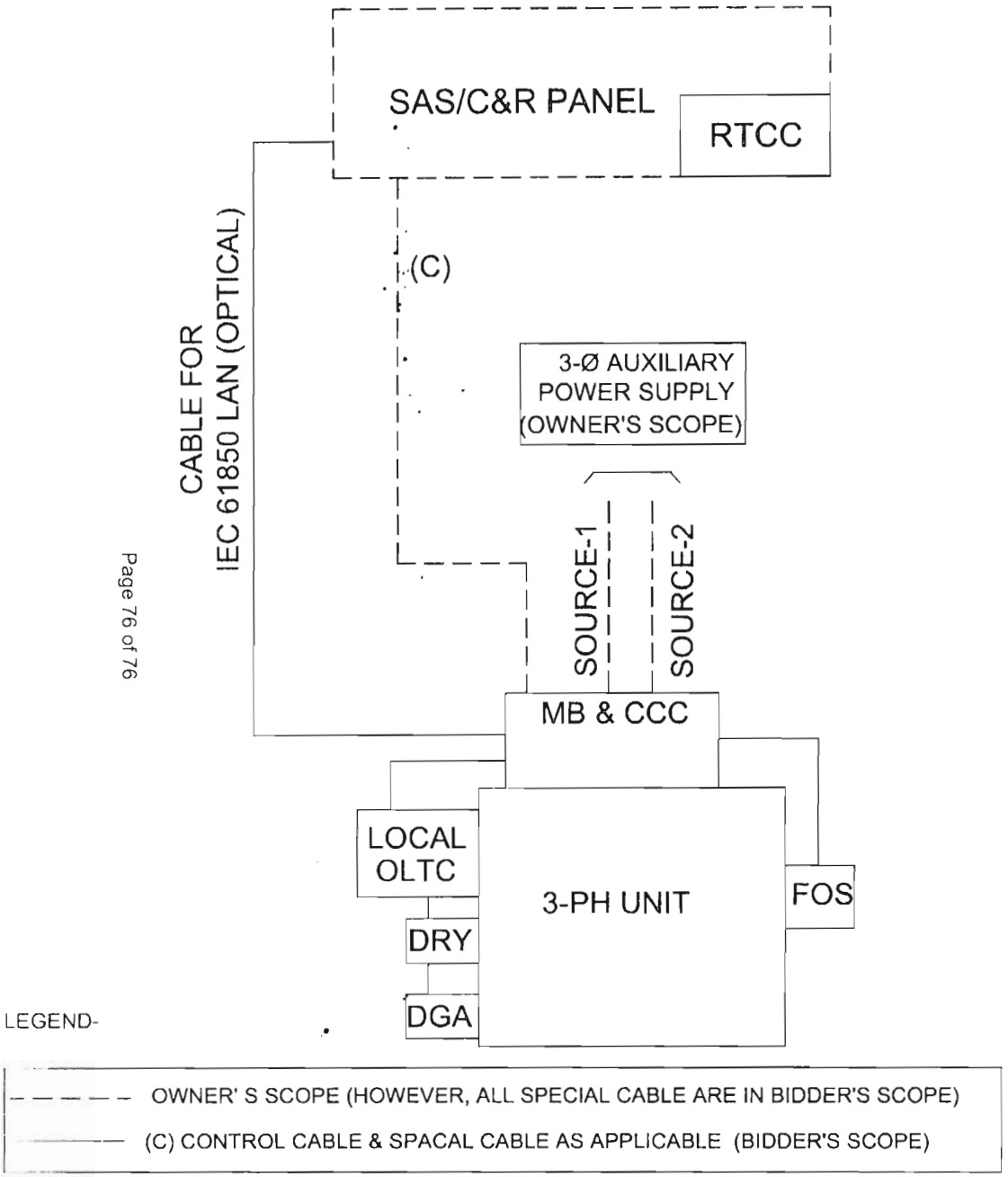
PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG NO	REV.
			CONCEPTUAL DRG. FOR OPTICAL FIBER SENSOR	C/ENGG/STD/OPICAL FIBER SENSOR/AT-SR	0



ee. Managed Ethernet switch, LIU patch cords etc. shall be provided in CMB/MB. All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

NOTE

1. MANAGED ETHERNET SWITCH, LIU PATCH CORDS ETC. SHALL BE PROVIDED IN MB ((BIDDER SCOPE OF SUPPLY).



NOTE-

1. MANAGED ETHERNET SWITCH, LIU PATCH CORDS ETC. SHALL BE PROVIDED IN MB ((BIDDER SCOPE OF SUPPLY).

2. SUPPLY AND LAYING OF POWER ,CONTROL AND SPECIAL CABLES FROM COMMON MARSHALLING BOX TO INDIVIDUAL MB (INCLUDING SPARE UNIT) & FURTHER DISTRIBUTION FROM IMB TO ALL ACCESSORIES IS IN THE SCOPE OF THE CONTRACTOR. FURTHER ANY SPECIAL CABLE (IF REQUIRED) FROM CMB TO OWNER'S CONTROL PANELS IS ALSO IN THE SCOPE OF THE BIDDER.

PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG NO	REV.
			CONCEPTUAL DRG. FOR SHOWING POWER & CONTROL CABLE FOR OPERATION OF 3-PH TRANSFORMER	C/ENGG/STD/CABLE/TR	0