



SECTION – 2.03

INVERTER DUTY TRANSFORMERS

1.0.0 INTENT OF SPECIFICATION

This specification covers the requirements of **Inverter Duty Transformers** for evacuation power from BESS power plants.

The Inverter Duty Transformer / BESS Transformer (IDT) is used to transform the low voltage to desired medium voltage of 11kV. The IDT shall have multiple windings maximum of up to 4 numbers in low voltage side and shall have single (1) high voltage winding which shall be suitable for outdoor installation.

2.0.0 SCOPE OF WORK

2.1.0 The scope of work shall include the following equipment.

- 11kV on HV side, voltage level on LV side shall be decided by bidder based on the PCS voltage level, three phase, Step up Inverter Duty transformers with OCTC, Bushing CTs for the BESS plant
- Nitrogen Fire Protection System shall be considered for each transformer for 10MVA and above.
- Foundation Plinth with rail arrangements
- Foundation bolts

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, IEC publications and any other standards of latest edition including amendments, except where modified and /or supplemented by this specification.

| | |
|--------------------------------------|------------------------------------------------|
| IS 2026 (Part I to IV), IEC 60076 | Transformers |
| IEC 60076-7, IS 6600 | Guide for loading of oil immersed transformers |
| IEC 60542 | Tap Changer |
| IS 5120, IS 3639 | Fittings and accessories for transformers |



| | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| IS 12463 | Insulating oil for transformer |
| IS 2099, IEC 60137 IS 12676 | Transformer Bushings |
| IS 3347 | Dimensions for Porcelain Transformer Bushings |
| IS 2629 | Recommended Practice for hot dip galvanizing of iron and steel |
| IS 2705 | Current Transformers |
| IEC 61869-3:2011 / IS 3156 | Voltage transformers |
| IS 2633 | Methods of testing of coating of zinc coated items |
| IEC 60296 | Transformer Oil |
| IS 3637 | Gas and Oil Operated Relay |
| IS 2026 | Transformers |
| IS 335 | New insulating oils – Specification |
| CBIP No. 295 | CBIP Manual on Transformers Publication |
| Regulations laid by the office of the Chief Electrical Inspector to Government. | |
| BEE Guidelines | |
| CEA Regulation on Technical Standards for Construction of Electrical Plants and Electric Lines, 2022. | |
| Latest additions of (as applicable as on date of bid submission) NFPA, HEI, ANSI, ASME, ISI, TEMA, AWS, NEMA, IEC, EJMA, codes and standards shall also apply, Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in the specifications. | |

4.0.0 DESIGN CRITERIA

- 4.1.0 Inverter Duty Transformer shall have electrolytic grade Copper / Aluminium windings, free from scales and burrs.
- 4.2.0 Inverter Duty Transformer shall have shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as per relevant applicable standards and PCS manufacturer recommendation. Also, each shield winding shall be taken out to tank with two separate connections from shield to bushing with



- proper support with 2 nos. 3.6 kV shield bushings and same shall be brought down along with support insulator from tank & copper flat up to the bottom of the tank for independent grounding.
- 4.3.0 Harmonic Factor as per PCS manufacturer recommendation must be considered while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the DC bias component of 0.5% of rated PCS output current is to be accounted for its effect on the transformer design.
- 4.4.0 The thermal design of Inverter Transformer needs to consider the temperature dependent performance of the PCS. It is to in accordance with PCS output and under worst condition it should not limit PCS output.
- 4.5.0 The multi-winding transformer needs to be designed for long term operating conditions with asymmetrical load on LV side i.e., in case three winding design, the transformer needs to operate reliable with only one PCS supplying power to only one LV winding. IDT should be provided with separate galvanically isolated low voltage windings for each PCS.
- 4.6.0 For multi winding transformer, it is recommended to have close coupling and equal impedances on each of LV winding to HV winding and to have high enough impedance (8% min. based on one LV winding rating) between two LV windings in order to decouple these windings.
- 4.7.0 Inverter transformer shall be proven and of successfully type tested design.
- 4.8.0 Contacts from Inverter transformer fittings/protection devices shall be wired for tripping of Inverter transformer Circuit Breaker. Detailed scheme regarding same shall be finalized during detailed engineering.
- 4.9.0 Power rating of inverter transformer shall not be less than total rated capacity of respective PCSs at any temperature within the operating temperature limits.
- 4.10.0 Inverter duty transformer no load voltage ratio shall be selected considering the voltage regulation such that the transformer shall be practically possible to function at nominal tap when fully loaded at 0.98pf.
- 4.11.0 Efficiency of the Inverter Duty Transformers at different loading and power factor (0.8 lag to unity) shall be minimum of 98.75%.
- 4.12.0 Each Inverter Transformer shall internally have multi Winding configurations with multi-LV windings and one HV Winding. there shall be only one Cable Box on the HV side and separate cable box for each LV winding. Winding configuration shall be as per LT panel/PCS rating.
- 4.13.0 Transformer rating shall be finalized as per PCS rating at 51°C.
- 4.14.0 Following Limit of hot spot temperature for which the transformer is designed over the maximum yearly weighted average ambient temperature (°C) shall be provided:
- 4.15.0 Hot Spot Temp. based on the design ambient of 51°C with hot spot factor 1.3 and the absolute hot-spot temperature shall not exceed 140°C under any rated operating condition as per IEC 60076-7.
- 4.16.0 At ambient of 51°C, OTI 35°C and WTI 40°C shall be considered during transformer design.



- 4.17.0 Impulse strengths of the HV windings shall be 75kVp and 40kVp for LV windings.
- 4.18.0 Two (02) CCA arrangement shall be considered in case of multi winding transformer.
- 4.19.0 Separate LV box shall be provided for each LV winding.
- 4.20.0 The Inverter Transformer shall have ONAN type cooling arrangement.
- 4.21.0 The Inverter transformer shall have off circuit tap changer with suitable numbers of taps
- 4.22.0 The Contractor shall submit all relevant calculations and drawings/ data sheets/ guaranteed parameters of the Inverter Transformers to the Purchaser for approval prior to commencement of manufacturer.
- 4.23.0 For transformer differential protection (as applicable), separate CT shall be provided at HV & each LV box and class of CT shall be PS only.
- 4.24.0 LV Box need to design in such a way that it should be suitable for 06 runs of cable per phase (tentative) and the terminal configuration and requirements may vary and shall be finalized during detailed engineering.
- 4.25.0 Baffle wall wherever applicable shall be provided as per IE Rules.
- 4.26.0 In case a built-in disturbance recorder (DR) is not available in the PCU with the following specifications/features, separate instrument transformers shall be provided as specified below:
- Time resolution: Better than 10 ms
 - DR shall be integrated with SAS/SCADA/BESS monitoring system on a real-time online basis
 - Pre-fault and post-fault recording time shall be at least 10 seconds each for every channel. The duration shall be user-programmable.
 - The DR system shall be capable of simultaneous recording of all channels.
 - The system shall have storage capacity to retain disturbance records for a minimum period of 6 months.

DR management, including configuration, settings, and data retrieval, shall be user-accessible without requiring intervention from the OEM. The DR system shall capture multiple channels including, but not limited to:

- Currents (all phases)
- Voltages (all phases, phase-to-phase and phase-to-neutral)
- Frequency
- Major inverter faults (LVRT, HVRT, and other inverter faults)

Instrument transformers (CTs and PTs) for disturbance recording shall be provided for future use by the owner for all LV windings and for all phases.

Current Transformers (CTs)

In case differential protection is not applicable, protection class CTs (5P20) shall be provided. However, if transformer differential protection CTs are installed, the same PS class CTs shall be utilized for disturbance recording (DR), and no separate 5P20 CTs shall be required.



The CT secondary wiring shall be brought out up to the marshalling box. Stud-type disconnecting terminal blocks along with ring-type lugs shall be provided. The CT secondary terminals shall be equipped with suitable shorting links for safe short-circuiting during maintenance.

Potential Transformers (PTs)

Protection class LV PTs shall be provided with current-limiting MCCBs on the primary side. PTs shall be installed in a suitable enclosure (mounted near or on the IDT). MCCBs shall be provided on the secondary side.

5.0.0 CONSTRUCTIONAL FEATURES

5.1.0 Tank

- a) The transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and cover shall be of welded construction and there should be provision for lifting by crane.
- b) At least two adequately sized inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided, one at each end of the tank. The inspection hole(s) shall be sufficient size to afford easy access to the lower ends of the bushings, terminals, each winding etc.
- c) The exterior of tank and other steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of an oil and weather-resistant nature, preferably of distinct colour from the prime and finish coats. The final coat shall be of with 2 coats of glossy, oil and weather resistant non-fading epoxy-based paint of colour shade RAL 7035.
- d) The interior of the tank shall be cleaned by sand blasting and painted with two coats of heat resistant and oil insoluble insulating varnish of white shade.
- e) All bolts and nuts exposed to atmosphere shall be galvanized. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets that shall give satisfactory service under the operating conditions for complete life of the transformer, if not opened for maintenance at site.
- f) Transformer tank shall be mounted on bi-directional rollers for rail gauge suitable as per IS / CBIP. Suitable locking arrangement shall be provided to prevent accidental movement of transformer. Tank shall also be provided with lifting lugs and minimum four jacking pad.
- g) The tank together with radiators, conservator, bushings and other fittings shall be designed to withstand the following conditions without permanent distortion:



- h) Full vacuum (mm of Hg – value as per latest CBIP Manual), for filling with oil by vacuum. Internal gas pressure of 0.35 Kg/cm² (5 lbs/sq.in) with oil as at operating level.
- i) The transformer shall have conservator tank of adequate capacity to accommodate oil preservation system and volumetric expansion of total transformer oil. The conservator shall be bolted into position so that it can be removed for cleaning purposes.
- j) The conservator shall be of single compartment type. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal.
- k) The tank cover shall be suitably sloped so that it does not retain rainwater. The material used for gaskets shall be cork, neoprene or approved equivalent.

5.2.0 Core

- a) The magnetic circuit shall be of core type. The core shall be constructed from high grade, non-ageing, cold rolled, super grain-oriented silicon steel laminations (CRGOS) equivalent to M3 grade steels or better.
- b) The insulation structure of the core to clamp plates shall be such that it withstands a voltage of 2kV (rms) for one minute in air.
- c) Adequate lifting lugs will be provided to enable the core & windings to be lifted.
- d) The core design shall be such as to limit the flux density to 1.7 Tesla at principle tap.
- e) Transformer shall also withstand following over-fluxing conditions due to combined voltage and frequency fluctuations:
 - f) 110% for continuous rating
 - g) 125% for at least one minute
 - h) 140% for at least five seconds
- i) Vendor shall furnish over-fluxing characteristics up to 150% during detailed engineering.
- j) The transformer shall also be capable of withstanding without damage during the time, for a duration of at least two seconds the stresses caused by short circuit limited only by the transformer impedance with 110% rated voltage maintained at source end.
- k) Grade of core shall be M3 or better.

5.3.0 Windings

- a) Windings shall be of Electrolytic grade Copper / Aluminium material.
- b) Windings shall have uniform insulation.



- c) Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratios.
- d) The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with transformer oil after the drying process to ensure elimination of air and moisture within the insulation.
- e) Windings shall be made in dust proof and conditioned atmosphere.
- f) For winding insulation, Kraft Paper (Shall not be older than 1 year at the time of construction of winding) For LV Foil winding diamond dotted kraft paper shall be used (ABB make only) The insulating material and insulating paper shall be kept in controlled environment as per recommendation of OEM. Bidder shall demonstrate the same during stage inspection.
- g) To avoid shrinkage during operation, windings shall be subjected to shrinkage treatment.
- h) The winding assembly should be full vacuum dried and then impregnated immediately in Transformer oil.
- i) Windings and connectors shall be braced to withstand shocks due to rough handling, and forces due to short circuit, switching or other transients.
- j) Permanent current carrying joints in winding and leads shall be brazed.
- k) Coils shall be supported at frequent intervals using dried and high-pressure compressed wedge type insulation spacers to ensure proper oil circulation.
- l) Coil assembly shall be dried in Vacuum oven process only. Hot air drying shall not be accepted. The oil shall be filled in the tank only thru vacuum process.
- m) The bidder shall furnish details of the above facilities available at his works along with the bid.
- n) Insulating materials shall be compatible with Transformer liquid under all service conditions.
- o) Winding & Connector Shall be braced to withstand shocks due to rough handling & forces due to short circuit, switching or other fast transients due to semiconductor switching.
- a) Leads to the terminal board and bushings shall be rigidly supported. Insulation levels of the Transformer windings shall be rated as follows:



| Insulation levels of the Transformer | | |
|--------------------------------------|---------------------------------|---------------------------------|
| Voltage | Impulse Voltage (kV Peak) | Power Frequency Voltage (kV) |
| Low Voltage | 40 | 10 |
| 11kV | 75 | 28 |

5.4.0 Internal Earthing

- a) The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by copper strip connection to the tank.

5.5.0 Bushings:

- a) Bushings shall be designed and tested to comply with the applicable standards. If type test certificates are not available, these tests shall also be carried out in addition to the routine tests. Bushings rated for 400A and above shall have non-ferrous flanges and hardware. Bushings shall be supplied with terminal connector clamp suitable for connecting the cables.
- b) No arcing horns to be provided on the bushings.
- c) Inverter Transformer LV bushing palms shall be silver/tin plated.
- d) Epoxy bushing to be provided for LV Side.
- e) Porcelain bushing to be provided for HV Side
- f) The Inverter Transformer bushing shall be of epoxy coating.

5.6.0 Cable boxes and Disconnecting chambers:

- a) Cable boxes shall be supplied with gland plates having holes to suit specified cables.
- b) Cable boxes / disconnecting chambers shall be provided with body earth terminals.
- c) LV cable boxes shall be provided with necessary LV bushings, bus bars, bus bar supports for making cable terminations.
- d) HV cable boxes shall be provided with necessary HV bushings and terminals for making cable terminations.



- e) Cable boxes shall be provided with suitable gaskets to ensure the specified protection class requirement (IP55). Cable boxes / disconnecting chambers shall be provided with necessary arrangements to prevent entry of rainwater into the same.
- f) Disconnecting chambers:
- g) Disconnecting chambers shall be provided to enable the transformer to be removed without unsealing the cables or draining oil from the main tank.
- h) Disconnecting chamber shall be air insulated and complete with seal-off bushings, removable flexible connectors / links, support insulators and removable covers.
- i) Phase-to-phase and Phase-to-ground clearances within the chamber shall be such as to enable either the transformer or cable to be subject separately to HV tests.
- j) Internal surface of cable boxes shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 80 microns.

5.7.0 Cable entry on LV side:

- a) Three wire system, Bottom Entry of cables.
- b) Cable shall be in bidder's Scope. Cable Gland Lugs and SS hardware for connecting cable on LT bus bar shall be in bidder scope. Bidder shall provide hole on the bottom side gland plate of LV cable box for cable entry. Cable Gland is nickel plated brass gland of double compression type of reputed make.
- c) Cable size, number of runs, Cable OD etc. shall be finalized during detailed engineering.

5.8.0 Cable Entry on HV Side

- a) Three wire system, Bottom Entry of cable.
- b) Cable Gland Lugs and SS hardware for connecting cable on HT bus bar shall be in bidder scope. Bidder shall provide hole on the bottom side gland plate of HV Cable box for cable entry.
- c) Cable size, number of runs, Cable OD etc. shall be finalized during detailed engineering.
- d) Neutral bushings
- e) The neutrals of the star connected HV windings shall be brought out to separate bushing terminals.
- f) The neutral bushings shall be provided on the tank at location that facilitates connecting to the earth chamber. Transformer HV Neutral Earthing shall be done as per system requirement. Neutral of Transformer if not required to be earthed, should be taken out through bushing and covered by insulating cap.



- g) CTs shall be of adequate rating for protection (differential, REF and others if any) as required, WTI etc. All CTs (except WTI) shall be mounted in the turret of bushings/bushing bottom (cable box); mounting inside the tank is not permitted.
- h) All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

5.9.0 Marshalling box

- a) Marshalling box shall be tank mounted, outdoor and weather/vermin/dust proof (protection class IP55), sheet-steel (2mm thick minimum) enclosure, with hinged door having padlocking facility and painted. The Marshalling box shall be fabricated using cold rolled sheet and with a sloping roof.
- b) Marshalling box shall have proper lighting and thermostatically controlled space heaters.
- c) All doors, covers and plates shall be fitted with neoprene gaskets. Bottom shall be at least 450 mm above floor level and provided with gland plate and cable glands as required. Top surface shall be sloped to drain off water falling on the box.
- d) It shall be in the bidder scope to provide the interconnection cabling between the marshalling box and all the accessory devices of transformer by either PVC insulated unarmoured cables routed through GI conduit (or) PVC insulated, armoured cables.
- e) Necessary cable glands shall be provided at the marshalling box for the above-mentioned cables as well as for terminating the incoming cables from remote panels.
- f) One dummy terminal block in between each trip wire terminal shall be provided. The terminal blocks shall be ELMEX 10 mm² or approved equal. At least 20% spare terminals shall be provided on each panel.
- g) The gasket used shall be of neoprene rubber.
- h) Wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.
- i) Internal surface of marshalling box shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 80 microns.
- j) All the incoming cables shall enter the marshalling box from bottom.
- k) All outgoing connections from the Transformer shall be connected to the Marshalling Box. It shall be enclosed in a metal casing and be weather and dust proof with a minimum of IP 55 certification.



- l) The temperature indicators shall be mounted at about 1600 mm from ground level.
- m) Space heater & panel light with door limit switch, 5/15 amp power socket & removable gland plate.
- n) The Marshalling Box shall have necessary accessories such as locks, glands, Toughened glass doors, terminal boards, Space heater, WTIs, OTI and all other appropriate equipment as required.
- o) All internal cable shall be FRLS only.

5.10.0 Terminal block wire connections:

- a) Fully enclosed with removable covers & made of molded, non-inflammable plastic material with blocks & barriers molded integrally.
- b) TBs shall be 1100V grade, 10Amp. One dummy terminal block in between each trip wire terminal shall be provided
- c) 20% uniformly distributed spare TBs to be provided. All control, alarm & indication devices provided shall be wired to TB's.
- d) Suitable for 2x2.5 sq mm Copper wire each side Terminal board rows shall be spaced adequately not less than 100mm apart to permit convenient access to wires and terminations. No components (except heater & its switch, light & sockets) shall be mounted on side & top wall of Marshalling Box e.g. MCBs. TBs etc.
- e) CT terminals Shall be provided with test links & isolating facilities.
- f) All CT terminals shall be provided as fixed Box type terminals on the Marshalling Box to avoid any hazard due to loose connection leading to CT opening or any other loose connection.
- g) In no circumstances Plug In type connectors shall be used for CT connection
- h) Minimum clearance with cable gland plate shall be minimum 200 mm
- i) Rain hood needs to provide for marshaling box.
- j) Illumination lamp with door limit switch needs to consider.

5.11.0 Transformer oil

- a) Transformer Oil shall conform to the requirements of IS:335. Transformers shall be supplied complete with transformer oil. No inhibitors shall be used in the oil.



- b) In case transformer is supplied partially filled with oil, oil required for topping up shall be supplied in non-returnable sealed containers along with main consignment to avoid any shortage of oil at the time of topping up of oil at site.

5.12.0 Radiator

- a) Enough radiators shall be made to meet the requirement of temperature rise.
- b) Radiators shall be detachable type directly mounted or separately mounted. Flanged, gasketed and bolted connections shall be used for connecting the radiators to the tank.
- c) Radiators shall be individually tested for leakage and pressure test etc. before connecting to tank.
- d) Each radiator shall have top and bottom shut off valves, top filling plug, bottom drain plug, lifting lugs, thermometer pockets at inlet and outlet pipes, air release devices, earthing provisions, filter valves and all other necessary accessories required.
- e) Radiator valves must indicate open and close direction clearly.
- f) Radiator thickness shall be 1.1 mm.
- g) Radiation sizing calculation needs to provide.
- h) In case of 50% radiators failure, transformer at full load shall operate at least 10 min without exceeding hotspot temp. of 140 deg C.
- i) Radiator cooling calculations should be done considering only radiator for cooling not transformer body

5.13.0 Valves

- a) All valves up to 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. Sampling & drain valves should have zero leakage rate.

5.14.0 Gaskets

- a) Gasket shall be fitted with weatherproof, hot oil resistant, rubberized cork gasket. If gasket is compressible, metallic stops shall be provided to prevent over compression.
- b) The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, bidder shall rectify the same & establish for a further period of 3



months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

- c) All gasketed joints shall be provided with canopy (inverted U-shape).

5.15.0 Conservator and Breather

- a) Conservator with Oil Level Gauge and plain Silica Gel Breathing Device shall be mounted integral with the tank in such a manner that the lowest oil level bushings remain under the head of liquid under all times.
- b) Conservator with aircell needs to consider. It should be replaceable type.
- c) Conservator shall be provided with Oil filling cap Oil draining plug Diaphragm
- d) Volume of the Conservator shall meet the requirement of expansion of total oil in Transformer and cooling equipment from minimum ambient to oil temperature of 90oC.
- e) Magnetic oil level gauge with metallic canopy Required with potential free contacts for low level alarm & indication. Metallic canopy to be provided to prevent ingress of rainwater.
- f) Air cell made of flexible urethane / Nitrile rubber reinforced with nylon cloth.
- g) Operating temp of Aircell shall be 100 deg C continuous
- h) Isolation valve between conservator & tank need to provide.
- i) Conservator volume shall be 15% of total oil Volume of transformer
- j) The oil filling hole shall have a cap and suitable drainage valve to completely drain the oil.
- k) One end of Conservator shall be bolted to facilitate cleaning.
- l) Breathers shall be mounted at approximately 1400 mm above ground level.
- m) One Prismatic Type Oil Indicator should also be provided on the Conservator.
- n) One Magnetic Oil Gauge with provision for low levels alarm shall be mounted on the Conservator to indicate the minimum normal and maximum levels.
- o) Testing, filling and shutoff valve needs to provide for conservator.

5.16.0 LV & HV cable Termination:

- a) LV cable box with disconnecting chamber.
- b) Minimum clearance from gland plate to bus bar shall be 800mm
- c) The HV termination should be through a bus bar arrangement (50X6 mm tinned copper) with flexible expansion connection & supported by 12 KV class insulators. Creepage distance for Support Insulator shall be minimum 372 mm.



- d) Cable boxes shall have removable top cover & ample clearance shall be provided to enable either transformer or each cable box to be subjected separately to high voltage test.
- e) The LV side terminations shall be done through tinned copper flexible & LV tinned copper busbar.
- f) The Trafo. LV busbar should be supported by suitable insulator (6.6 KV) at minimum three places from cable box. The hole to hole spacing in LV Busbar shall be minimum 75mm for cable lug termination.
- g) The LV cables shall be terminated on LV busbar with side by side cable termination arrangement (18Nos. terminations in one side). Back to back cable termination is not acceptable for LV busbar cable connection.
- h) LV cable box clearance
 - i) Phase to Phase: 180mm (min)
 - j) Phase to Earth: 150mm (min)
- k) In HV & LV cable box, FRP Plate (Min 5mm thick) partitioning between phase to phase terminals throughout the box. The FRP fixing shall be detachable type such that during cable termination it shall be possible to remove the plate and fix later on.
- l) FRP separation shall be provided between each phases of each LV windings.
- m) Gasket (Rubberized cork sheet) for inspection covers/ door shall be minimum 8 mm thick.
- n) Sheet thickness for HV& LV cable box shall be 3 mm (minimum).
- o) HV& LV cable box enclosure shall have IPW-55 DOP.
- p) Additional Inspection Covers with handles shall be provided on top of the LV cable box to access the flexible & termination.
- q) Provision for armour earthing thru GI strip of adequate size will be provided at Left / right side of HV cable box.
- r) Paint Shade shall be RAL 7035.
- s) Hot dip Galvanized iron (GI) and the support shall be from ground (Up to below 500 mm from Rail level.) along with GI structure for cable clamping support. For each HV cable Box minimum two supports and for each LV Cable box min. four support structures shall be provided from ground. Number of supports shall be subjected to Purchaser's approval during detail engg. HV, LV cable boxes and radiator support shall preferably GI ISMC channel of adequate size.



- t) Non-ferrous (aluminum minimum 6mm thick) for LV and HV (Shall be split into 2 parts). Cutout in LV gland plate to be made at works as per owner's requirement. Cutout to be drilled in gland plate (size shall be intimated during GA drawing Approval). The no. of cutout / hole / hles shall be :- HV Side as per requirements' : -
- u) LV side: - Standard LV gland plate Cut out detail is enclosed for bidder's reference.
- v) The dimension of gland late shall be decided by bidder based on dimension of cable box and glanding system.

5.17.0 Fittings And Accessories

- a) The transformer shall be complete with oil for first filling and all standard fittings and accessories as per IS 2026 including the following:
 - b) First fill of oil as per IS2026
 - c) Oil conservator with filling hole, cap, and air cell separator for the main and OCTC oil compartments.
 - d) Drain plug for conservator.
 - e) Magnetic oil level gauge with alarm contacts
 - f) Prismatic oil level indicator
 - g) Cobalt free Silica gel breathers for conservator
 - h) Double float Buchholz relay with alarm and trip contact
 - i) Shut off valve for Buchholz relay on both sides.
 - j) 150 mm dia with angular sweep of 270° Dial type oil temperature indicator with alarm, trip contacts and maximum temperature indicator along with 4-20 mA transmitter.
 - k) 150 mm dia with angular sweep of 270° Dial type CT operated winding temperature indicator with alarm, trip contacts and maximum temperature indicator along with 4-20mA transmitter for each winding.
 - l) Thermometer pockets with two nos spare pockets
 - m) Pressure relief valves as per CBIP / CEA regulations with trip and alarm contacts.
 - n) Air release vent, drain plug for radiators.
 - o) Flanged filter valve at top and bottom
 - p) Lifting lug and jacking pads
 - q) Rating and terminal marking plate



- r) Bi-directional flanged wheels
- s) Detachable radiators complete with top and bottom valves.
- t) The winding end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.
- u) Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.
- v) In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.
- w) Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.
- x) Extended Rain hood shall be provided for PRV, Buchholz, MoG, NIPFS sensors (as applicable) , Signal Box, Marshalling Box, LV PT Box, any other similar device / item.

6.0.0 TESTS

All tests shall be carried out using its' own accessories and parts which shall be supplied along with the transformer.

6.1.0 Type Tests

Following type tests shall be conducted on one transformer as per IS: 2026/ IEC-60076//CBIP Manual:

- Type Test of the transformer shall be carried out in accordance with IS: 2026.
- In case the transformer manufacturer has conducted all type tests required as per IS 2026 within last ten years, as on the date of bid opening, the type test reports have to be submitted to Employer for waiver of conductance of such type test(s). These reports shall be for the tests conducted on equipment similar to those proposed to be supplied under this contract and test(s) shall have been either conducted at an independent laboratory or shall have been witnessed by an Employer's representative. Any other additional cost involved in this regard shall be on bidder's scope.
- In case the type test for the transformer has not been conducted or the test report not meeting the specification requirement for the offered transformer manufacturer, the theoretical evaluation of the ability to withstand the dynamic effects of short circuit, based on the calculation and consideration of the design characteristics and manufacturing practices shall be carried out as per IS 2026-5/IEC 60076-5. Necessary



design document and reference test reports related to theoretical comparative evaluation should be submitted by bidder. Any other additional cost involved in this regard shall be on bidder's scope.

6.2.0 Routine Tests

6.2.1 Following routine tests shall be conducted on each transformer as per IS: 2026/ IEC-60076/CBIP Manual:

- Oil Leakage Test on completely assembled transformer (with radiator assembly) -
- All tank & oil filled compartment shall be tested for oil tightness by being completely filled with oil of viscosity not greater than that of specified oil at the ambient temperature & applying pressure equal to the normal pressure plus 35 kN / m² measured at the base of the tank. The pressure shall be maintained for a period of not less than 24 hours during which time no sweating shall occur.
- Tan Delta test
- Temperature Rise Test (25% of the IDTs)
- PT VT test of Tank (100%)
- All tank, radiator and CCA inspection shall be in witness category
- Conductor measurement during the stage inspection as well as flux and current density measurement as per actual dimension.
- SFRA

6.3.0 Special Tests

Following Special tests shall be conducted on each transformer as per IS: 2026/ IEC-60076 /CBIP Manual:

- Temperature Rise test as per IS 2026
- Tank Vacuum & Tank Pressure Test as per CBIP

6.4.0 Other than tests mentioned above the following specific tests to be conducted on transformers during pre-commissioning at site:

- After erection at site all transformer(s) shall be subjected to the following tests:
- Insulation resistance test
- Measurement of Voltage Ratio
- Polarity test
- Magnetic Balance test
- Dielectric test on oil
- Physical check
- Breakdown voltage on transformer oil. Oil filtration (if Oil BDV is not satisfactory)
- SFRA
- Any other tests as required by statutory authorities

6.4.1 Inspection and testing of transformers.



- Bidder shall provide inspection call to Employer for all routine, type and special tests are per relevant clauses. Prior to the call, bidder shall submit the detailed manufacturing quality plan (MQP) format for approval. Inspection shall be carried out jointly by Employer and Vendor.

7.0.0 NIFPS for Inverter Duty Transformer

1. Each transformer shall be provided with a dedicated Nitrogen Injection system. It shall act as a fast and effective fire fighter without employing water or carbon dioxide. Fire shall be extinguished within 3 minutes of system activation and within 30 seconds of commencement of nitrogen injection. Nitrogen Injection system shall consist of the following components.
2. Fire Extinguishing Cubicle placed on a plinth at a distance of about 5 m away from transformer. The cubicle shall be enclosed in civil structure (three sided with roof) of appropriate size considering ease of approach for manual operation in case of fire. The system shall be connected to the top of transformer oil tank for depressurization of tank and from its bottom through oil pipes to the steel oil tank (capacity min. 10% of total volume of oil in transformer). The cubicle should house a pressurized nitrogen cylinder, connected to the oil tank of transformer. The Transformer Conservator Isolation Valve (TCIV) shall be fitted between the conservator tank and Buchholz relay. The Cubicle shall be made of CRCA sheet of 2 mm (minimum) thick complete with the base frame, painted inside and outside with post office red colour (shade 538 of IS -5). The degree of protection shall be IP55 (minimum). The following items shall be provided in the Cubicle.
 - Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer.
 - Oil drainpipe with mechanical quick drain valve.
 - Electromechanical control equipment for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas.
 - Pressure monitoring switch for back-up protection for nitrogen release.
 - Limit switches for monitoring of the system.
 - Butterfly valve with flanges on the top of panel for connecting oil drainpipe and nitrogen injection pipes for transformer.
 - Oil drainpipe extension of suitable sizes for connecting pipes to oil pit.
 - Panel lighting and Space heater.
3. A pit / sump of appropriate size in a corner of the tank shall be provided by Employer with adequate slope to facilitate suction of the pump for complete emptying of the tank.
4. Specifications for cover of Soak oil / Burnt oil tank shall be as per below (as per the IE Rules):
 - Size: 600 X 600 mm
 - Material: Cast Iron
 - Type: Heavy duty Airtight
5. A Control box shall be used for monitoring system operation, automatic control and remote operation. Separate control box for each transformer is to be provided. Enclosure of control box



shall be of reputed Make only. Two or more transformer control box in one enclosure shall not be acceptable. Potential Free contacts shall be available for alarm troubles for input to Supervisory Control and Data Acquisition System (SCADA) / Energy Management System (EMS). A separate hooter & emergency trip provision shall be provided in main control room. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided. Only DIN mounted auxiliary contactors (of approved vendor) with or without add-on block are to be provided for signaling / contact multiplication etc. Use of miniature relays shall not be acceptable.

- System ON.
 - TCIV open.
 - Oil drain valve closed.
 - Gas inlet valve closed
 - TCIV closed
 - Detector trip
 - Buchholz relay trip
 - Oil drain valve open
 - Extinction in progress
 - Cylinder pressure low
 - Differential relay trip
 - PRD / RPRR trip
 - Transformer trip
 - System out of service
 - Fault in cable connecting fault detector
 - Fault in cable connecting differential relay
 - Fault in cable connecting Buchholz relay
 - Fault in cable connecting PRD
 - Fault in cable connecting transformer reactor trip
 - Fault in cable connecting TCIV
 - Auto / Manual / Off
 - Extinction release on / off
 - Lamp test
 - Visual / Audio alarm for AC supply fail
 - Visual / Audio alarm for DC supply fail
6. Transformer conservator isolation valve (TCIV) shall be fitted in the conservator pipe line, between conservator and Buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in



the permissible normal operating conditions. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator. The TCIV should be of the best quality as malfunctioning of TCIV could lead to serious consequence. The closing of TCIV means stoppage of breathing of transformer. Locking plates shall be provided for pad locking. A suitable platform and ladder shall be provided to approach Buchholz relay and the TCIV valve for manual reset. The ladder shall be pad lockable cover right from FGL to avoid unauthorized climbing in transformer charged condition and with top handrail. Ladder shall start from 100mm above gravel level to Top of the transformer tank. The ladder shall have hand rail at top.

7. The system shall be complete with adequate number of detectors (quartz bulb) fitted on the top cover of the transformer oil tank. Detectors shall be connected in parallel to the signal box by Fire survival cables. Fire survival cables (capable to withstand 750 deg C.) shall conform to BS 7629-1, BS 8434-1, BS 7629-1 and BS 5839-1, BS EN 50267-2-1 or relevant Indian standards.
8. Signal box shall be mounted away from transformer main tank with approachable height from ground level, preferably near the transformer marshalling box, for terminating cable connections from TCIV & detectors and for further connection to be control box. The degree of protection shall be IP55 (minimum).
9. Fire Retardant Low Smoke (FRLS) cable shall be used for connection between control box to DC & AC supply source, FEC to AC supply source, signal box / marshalling box to transformer conservator isolation valve connection on transformer. Separate cables for AC supply & DC supply shall be used.
10. Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.
 - Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations.
 - Flanges between Buchholz relay and conservator tank for fixing TCIV.
 - Pipe connections between transformer and FEC and between FEC and oil pit required for collecting top oil.
 - Butterfly valves / Gate valves on oil drainpipe and nitrogen injection pipe which should be able to withstand full vacuum.
11. On receipt of all activating signals, the system shall drain - pre-determined volume of hot oil from the top of tank (i.e. top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.



12. Besides automatic control, remote electrical push button control at Control box and local manual control in the cubicle shall also be provided. Tripping of all circuit breakers (on HV & LV side) associated transformer is the pre-requisite for activation of system.
13. The following electrical signals shall be used for activating the system under prevention mode/fire extinguishing mode.
 - For prevention:
 - Differential relay operation.
 - Buchholz relay paralleled with pressure relief Rise Relay
 - For extinguishing
 - Fire Detector
 - Buchholz relay paralleled with pressure relief Relay.
14. The system shall be designed to be operated manually in case of failure of power supply to the system. It shall be ensured that once the system gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also, PRD shall get closed only if all the connected breakers are open.
15. The supplier shall demonstrate the entire functional test associated with the following as Factory Acceptance Tests:
 - FEC, Control Box
 - Fire Detector
 - Transformer Conservator Isolation Valve
16. The performance test of the complete system shall be carried out after erection of the system with transformer at site.

8.0.0 QUALITY CONTROL

Bidder shall submit the MQAP, FAT and FQP for the Inverter Duty Transformer (IDT).

9.0.0 WARRANTY

1. Bidder shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.
2. During the warranty period, whenever a technical problem is encountered with transformers, Employer will report the same to the Bidder. All parts of the transformers shall be covered under warranty. Replacement of all defective material during warranty period shall be in scope of the bidder.
3. Bidder shall ensure that the problem is attended to by their service engineer within two days from the date of reporting.

10.0.0 Installation & Commissioning Support

1. Supervision of erection/assembly of transformer fittings and accessories including marshalling box wiring. This shall include providing technical guidance to erection team wherever required.



2. Commissioning / service engineer(s) shall be available at site at the time of commissioning of the power plant. All necessary guidance / support in overcoming technical problems (if any) related to the transformers.

11.0.0 Documents / Drawings Required

Following documents shall be submitted to Employer along with technical offer:

1. Filled in values/details wherever the same is asked for in Employer technical specifications
2. Confirmation of NIL deviation to Employer Purchase Specification. In case any deviation is taken, bidder shall indicate the clause no., Employer requirement as per the subject clause and the deviation taken.
3. Bidder shall provide their deviations from the original specification in the bidder deviation sheet.

Documents to be submitted after receipt of purchase order

1. Following documents shall be submitted for Employer approval within seven days from date of purchase order:
2. Overall General Arrangement (plan, elevation, end view) with overall dimensions and BOM.
3. Rating plate details
4. Valve schedule plate details with elevation & side view showing valve positions
5. HV cable box with disconnecting chamber, bushings, gland plate, cable termination details etc.
6. LV cable box with disconnecting chamber, bushings, gland plate, cable termination details etc.
7. Marshalling box GA (front view, side view, bill of items) and wiring diagram
8. Foundation plan
9. Bill of material of transformer (BOM)
10. Un-tanking details (removal of core and assembly from tank)
11. Type Test Reports
12. Guaranteed technical specification of transformer as per IEC/IS standards.
13. Manufacturing Quality Plan (routine tests, type tests, test certificates) covering Incoming materials, in-process checks during manufacturing, final inspection, finished goods, packing, and forwarding.
14. Manufacturing clearance shall be subject to approval of the above documents by Employer /Employer.

12.0.0 Documents to be submitted along with consignment.

1. Following documents shall be submitted to Employer at the time of delivery of the consignment:
 - As built drawings of transformer
 - Routine test reports on transformer
 - Type test reports of transformer
 - Test certificate for transformer oil
 - Operations and maintenance manual of transformer in hard + soft copy



13.0.0 Support from bidder during document approval phase

1. During the phase of approval of design / engineering / quality documents (GA, GTP, BOM, MQP, Test report etc.), it will be required to hold in-depth discussions with Employer to provide clarifications through clear understanding of technical queries. (Note: All documents / drawings shall be supported by necessary computer inputs / outputs, wherever applicable)

14.0.0 Spares

| S.No | Equipment | Qty. |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| 1. | HV bushings with metal parts and gaskets | 1 sets (3 Nos) |
| 2. | LV bushings with metal parts and gaskets | 1 sets (6 Nos) |
| 3. | HV Neutral Bushing | 1 sets (1 Nos) |
| 4. | Set of valves (Each set shall represent complete qty of different types of gaskets used in one transformer. Total list of gaskets shall be indicated by bidder during detailed Engg) | 1set |
| 5. | Pressure relief device with trip contacts | 1 No |
| 6. | Winding temperature indicator with alarm & trip contacts along with 4-20mA transmitter | 1 No |
| 7. | Oil temperature indicator with alarm & trip contacts along with 4-20mA transmitter | 1 No |
| 8. | Buchholz relay (Complete unit) | 1 No |
| 9. | Magnetic Oil level Gauge (MOG) | |
| 10. | Set of Gaskets (Each set shall represent complete quantity of different types of gaskets used in one transformer. Total list of gaskets shall be indicated by bidder during detailed Engineering) | 1 Set |
| 11. | Transformer Oil | 10% of total quantity of extra oil required for all the transformer |
| 12. | Bus Bars with Jumpers for HV side (1 set is for all 3-Phases) | 1Set |



| | | |
|-----|-------------------------------------------------------------------------------|-----------|
| 13. | Bus Bars with Jumpers for LV side (1 set is for all 3-Phases of 1-LV winding) | 1Set |
| 14. | CTs of each Type, each Rating and each Make | 1 no each |
| 15. | PTs of each Type, each Rating and each Make (as applicable) | 1 no each |

Note: Bidder shall provide a complete list of spares showing item-wise unit price, quantity and total price.

15.0.0 TECHNICAL PARAMETERS

| Sl. No. | Description | Unit | Data offered (Bidder) |
|---------|-------------------------------------------------|------|-----------------------|
| 1. | Transformer Type | – | |
| 2. | IP class | – | |
| 3. | Application | – | |
| 4. | Core | – | |
| 5. | Rating | kVA | |
| 6. | No. of Phases | – | Three |
| 7. | No. of LV Windings | Nos | |
| 8. | Frequency | Hz | 50 |
| 9. | HV winding | kV | |
| 10. | LV winding | | |
| | LV1 winding | kV | |
| | LV2 winding | kV | |
| 11. | Winding material | – | |
| 12. | Winding insulation | – | |
| 13. | Neutral on HV side | – | |
| 14. | Vector Group | – | YNd11,d11,d11,d11 |
| 15. | Rated Thermal Short time current withstand time | S | |



| Sl. No. | Description | Unit | Data offered (Bidder) |
|---------|-------------------------------------------------------------------------------------|-------------------------|-----------------------|
| 16. | % Impedance on principal tap, on LV Winding Power base at 75deg C and 51 deg C | % | |
| 17. | Termination HV/LV/Orientation | – | |
| 18. | Cable entry on HV side | – | |
| 19. | Tapping on HV winding | – | |
| 20. | Loading Capability | – | |
| 21. | Ambient temperature | (°C) | |
| 22. | Temperature rise | % (or) (°C) | |
| 23. | Flux density | T (or) w/m ² | |
| 24. | Air Clearances | | |
| 25. | Core Losses | – | |
| 26. | Harmonics | % (or) kW | |
| 27. | Noise level | dB | |
| 28. | Highest system voltage | kV | |
| 29. | Insulation Class (Winding and bushing) | | |
| 30. | Insulation level (Impulse withstand voltage / Power Frequency withstand voltage) | | |
| 31. | Painting | – | |
| 32. | Constructional features | – | |
| 33. | Fittings and accessories | – | |
| 34. | Provision of Shielding | – | |
| 35. | No load current at rated voltage and frequency | A | |
| 36. | Efficiency at 75 Deg. C at UPF | % | |
| 37. | Maximum Efficiency (%) and load at which it occurs (kVA) | % @ kVA | |



| Sl. No. | Description | Unit | Data offered (Bidder) |
|---------|---------------------------------------------------------------------------------------------------|----------|-----------------------|
| 38. | Overall dimension Length x Breadth x Height | mm*mm*mm | |
| 39. | Oil capacity | L | |
| 40. | Weight of transformer | Kg | |
| 41. | Minimum creepage distance | mm/kV | |
| 42. | HV Side fault level | | |
| 43. | LV side Fault level | | |
| 44. | Short circuit withstand duration | S | |
| | Tank type | – | |
| | Details of Transformer Accessories | | |
| | Surge Impedance, Zero sequence Impedance, Zero sequence Reactance, Zero sequence Resistance | | |