

VOLUME-2
PART- I
Section-6
Generator Step Up and
Auxiliary transformers

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6. Generator Step-Up and Auxiliary Transformers

6.1 Intent of Specifications

The intent of these specifications is to define the scope of work under this section which covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, storage at site, erection, acceptance testing, commissioning, performance testing, handing over to Purchaser and guarantee of 2 nos. three phase Generator Step-Up and Auxiliary Transformers for Keyi Hydro Electric Project, Arunachal Pradesh as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

It is not the intention to specify the minute details/smallest items to deliver a functional system or to define the standard manufacturing practice but to outline the performance, constructional, operational and guaranteed requirements. It is the responsibility of the contractor to ensure these requirements.

6.2 Detailed Scope of Supply

6.2.1 Generator Step-Up Transformers

- Two (2) nos. 15 MVA, 11/132 kV, ONAN cooled, three phase step-up oil filled transformers complete with all necessary items such as bushings, undercarriage, off-circuit tap changer, radiators, instrumentation, fittings, marshalling box etc.
- Two (2) sets of valves, piping, mounting plates, hangars, hardware, etc. for the cooling system
- Oil spill collection and separation system. However soaking pit for oil collection is not in the scope of bidder.
- One (1) set of items not specified above but necessary for the satisfactory operation of all the two (2) transformers shall be included in the scope.
- All special devices, tools, maintenance equipment, consumables etc., required for installation, testing, commissioning and maintenance of the transformers.
- Necessary rails on foundation in the switchyard.
- Devices /equipment for integration of control, metering & monitoring with SCADA system
- Specified Spares
- Special Tools, if any
- One (1) lot of consumables required during erection

6.2.2 Auxiliary Transformers

- Two nos. 500 kVA, 11/0.433 kV ONAN, Oil filled type three phase station auxiliary Transformers for installation in Powerhouse.

- One nos. 100 kVA, 11/0.433 kV ONAN, Oil filled type three phase station auxiliary Transformers for intake power supply.
- Each of above transformers shall be ONAN cooled, three phase oil filled transformers complete with all necessary items such as bushings, cable box on 11kV as well as 0.433 kV sides, undercarriage, off-circuit tap changer, radiators, instrumentation, fittings, marshalling box etc.
- One (1) set of items not specified above but necessary for the satisfactory operation of all the above three phase transformers.
- First filling of oil and 10% extra for all above transformers.
- All special devices, tools, maintenance equipment etc., required for installation, testing, commissioning and maintenance of the above three phase transformers.

6.2.3 Services

- Site installation and successful commissioning.
- Field / touch-up painting including all painting materials.
- Performance and field acceptance testing as per the relevant clause of this section and submission of report.
- Training of Purchaser's personnel including operation and maintenance staff as defined in "Section 1 - General Technical Specification".
- All the technical documentation including preparation and submission of O&M manuals

6.3 Special Design and Layout Conditions

6.3.1 General

The location of all complete assembled transformers shall be as shown in layout drawings. All the control and instrumentation panels / devices shall be so arranged that these are easily visible and conveniently and safely accessible.

The Generator transformers shall be oil-immersed with ONAN cooling. All auxiliary transformers shall be ONAN cooling.

Transformer shall have sufficient clearance inside the tank to have internal inspection in-situ.

6.3.2 Design Consideration

6.3.2.1 11/132 kV GSU transformers

The generator step-up transformers (GSU) transformers shall be of proven design for intended duty specified to ensure a high reliability and availability. The generator step-up transformers shall be suitable for peaking duty and design shall be capable to withstand frequent start and stop sequence. The generating unit may be started up and shut down at least two times a day.

The power generated by three generators at 11 kV and paralleled at 11kV bus will be stepped up to 132 kV level by two nos. 11/132 kV, 15 MVA three phase step-up transformers.

Transformer LV side shall be connected to the 11 kV generator switchgear through 11 kV XLPE cables. A suitable cable box to receive XLPE cables per phase at LV end of the transformer shall be provided. The HV terminals of the transformers shall be brought out through 145 kV Oil/Air bushings and shall be connected to 132 kV Air insulated conventional switchyard through overhead conductor. The neutral winding for three phase alternative shall have star formation inside transformer tank with neutral terminal brought out of tank through 132 kV bushing for restricted earth fault protection & direct connection to ground mat.

6.3.2.2 Station Auxiliary Transformers

Two (2) nos. 11 KV/0.433 KV 500 KVA Station Auxiliary transformers shall be fed from the 11 KV switchgear. The 11 kV side incoming power connections shall be done by 11 kV XLPE cable and 0.433 KV side outgoing power connections shall be done by power cables.

6.4 Basic Dimensions and Ratings

6.4.1 Generator Step-Up Transformers

Continuous rating at 40°C maximum ambient temperature

| S. No. | Particulars | GSU Transformer |
|--------|--------------------------|---------------------|
| 1. | H.V. winding ONAN rating | 15000 kVA |
| 2. | LV winding ONAN rating | 15000 kVA |
| 3. | No. of phases | Three |
| 4. | Installation | Outdoor |
| 5. | Frequency of the system | 50 Hz± 5% |
| 6. | Voltage ratio | 11 /132 kV |
| 7. | Rated no load voltage of | |
| i. | H.V. winding | 132 kV (r.m.s.) |
| ii. | L.V. winding | 11 kV |
| 8. | Highest voltage of | |
| i. | H.V. Winding | 145 kV |
| ii. | L.V. winding | 12 kV |
| 9. | Type of cooling | ONAN |
| 10. | System earthing | Effectively Earthed |

| | | |
|------|--|------------------------------|
| 11. | Vector group | Ynd11 |
| 12. | Tap Changer | |
| i. | Type | Off circuit for HV variation |
| ii. | Range | From -7.5% to +7.5% |
| iii. | Steps | Each of 2.5% |
| iv. | Location | H.V. side |
| 13. | % Impedance at rated MVA and rated frequency, | As per IS 2026 |
| 14. | Dielectric levels (winding) | |
| i. | Power frequency withstand voltage | 275 kV (r.m.s) |
| ii. | Lightning impulse withstand voltage | 650 kV (peak) |
| iii. | Switching impulse withstand voltage H.V Winding | NA |
| 15. | Dielectric level - Bushings | |
| i. | Power frequency withstand voltage | 275 kV (r.m.s) |
| ii. | Lightning impulse withstand voltage | 650 kV (peak) |
| iii. | Switching impulse withstand voltage H.V. winding | NA |
| 16. | Max. flux Density at normal voltage, frequency and normal ratio | 1.72 tesla (Not to exceed) |
| 17. | Voltage withstand capacity during sudden disconnection of load | |
| i. | 1.4 times the rated voltage | For 5 seconds |
| ii. | 1.25 times the rated voltage | For 1 minute |
| iii. | 1.1 times the rated voltage | Continuous |
| 18. | Max. Winding hot spot temperature with a reference max. air temperature of 40°C. | 98°C |
| i. | Temperature rise of top oil measured by thermometer | 50°C |
| ii. | Temp. rise of winding measured by resistance | 55°C |
| 19. | Minimum creepage distance | |
| i. | HV bushing | 25 mm/kV |
| ii. | LV bushing | 25 mm/kV |
| 20. | Noise level | NEMA STANDARD TR-1 |

| | | |
|-----|---|---|
| 21. | Overload Capacity | As per latest IS: 6600 / IEC 60354 |
| 22. | Short circuit withstand capacity on HV side | As per IEC: 60076/IS 2026 |
| 23. | Minimum clearance in air: | |
| i. | LV terminal | As per IEC/IS |
| 24. | Insulation class: | |
| i. | HV winding | Class A Graded insulation |
| ii. | LV winding | Class A |
| 25. | Correction in withstand voltage due to high Altitude above 1000 m | As per relevant standard |
| 26. | Terminal Arrangement | |
| i | HV Phase Terminals | HV phase terminals shall be brought out through 145 kV oil bushing with terminals suitable for connection to ACSR Panther conductor |
| ii | LV Phase Terminals | Shall be Cable box suitable for connection to XLPE cable |

6.4.2 Auxiliary Transformers

All station transformers shall be either Core or shell type of construction, 3-Phase, outdoor type and shall be ONAN (oil filled, natural oil / natural air cooled) type.

The rating and electrical characteristics of the transformers shall be as follows:

| Sl. No. | Particulars | PH Station Aux. Transformer |
|---------|------------------------------------|---|
| (i) | Rated Output | 500 kVA and 100 KVA (for intake Supply) |
| (ii) | No. of Phases | 3 |
| (iii) | Type of Transformer | 2 winding, Outdoor type |
| (iv) | Frequency | 50 Hz |
| (v) | Rated Voltage | |
| | HV winding | 11 kV |
| | LV winding | 0.433 kV |
| (vi) | Highest System Voltage, HV | 12 kV |
| (vii) | Type of HV & LV winding Insulation | Uniformly Insulated |

| | | | | |
|---------|--|---|--------|--|
| (viii) | Cooling | ONAN (Oil Natural, Air Natural) | | |
| (ix) | Type of Tap changing gear | OCTC (Off circuit Tap changing gear) | | |
| (x) | Details of Taps | Full capacity taps on H.V. winding to give variation of +10% to -10% of rated voltage in steps of 2.5%. | | |
| (xi) | LV earthing | Neutral Solidly Grounded | | |
| (xii) | Class of Insulation | “A” | | |
| (xiii) | Temperature Rise over an ambient temperature of 40°C of | | | |
| | winding | 55°C | | |
| | Oil | 50°C | | |
| (xiv) | Insulation level of winding | HV | LV | |
| | Rated short duration power frequency withstand voltage | 28 kV | 3 kV | |
| | Rated lightning Impulse withstand voltage | 75 kV | | |
| (xv) | Insulation level of bushings / bushing insulators in cable box | 75 kV | 1.1 kV | |
| | Voltage class of bushings | 75 kV | 1.1 kV | |
| | Rated short duration power frequency withstand voltage | 28 kV | 3 kV | |
| | Rated lightning Impulse withstand voltage | 75 kV | | |
| (xvi) | Winding Connection | Delta | star | |
| (xvii) | Vector Group | Dyn11 | | |
| (xviii) | Neutral terminal to be brought out | On LV side | | |
| (xix) | Arrangement of terminal connections | On HV side through cable box for connection to 11 kV XLPE cables & on LV side through cable box for connection to 1.1 kV XLPE cable | | |
| (xx) | Impedance voltage | As per IEC 60076/IS 2026 | | |
| (xxi) | Correction in temperature rise due to higher altitude | Nil | | |
| (xxii) | Max. Flux. Density in core/yoke under over voltage conditions | Not exceeding 1.9 Tesla | | |

6.5 Codes and Standards

| | | |
|----|---|---------------------------------|
| 1 | Power Transformer | IS:2026 (Part I to IV)/IEC60076 |
| 2 | Transformers bushings | IS:2099/IEC 60137 |
| 3 | Current transformers | IS:2705/IEC 185/IEC 60044 |
| 4 | Transformer oil | IS:335 |
| 5 | Gas and oil operated relay | IS:3637 |
| 6 | Motors | IS:325 and IS:996 |
| 7 | Oil pumps | IS:5120 |
| 8 | Motor starters | IS:1822 |
| 9 | Fittings and accessories for power transformers | IS:3639 |
| 10 | Heat exchangers | IS:6088 |
| 11 | Dimensions for porcelain transformer bushings | IS:3347 |
| 12 | Loading guide for oil-immersed transformers | IS:6600/IEC 60354 |
| 13 | Partial Discharge Measurement | IEC 60270 |
| 14 | Manual on Transformers | CBIP PUB. 295 (2007) |
| 15 | Noise level | As per NEMA TR -1 |

Transformer, accessories, etc. meeting any other authoritative standard, which ensures equal or better quality than the Standards mentioned above, shall also be acceptable. However, where the equipment offered conforms to any other standards, the salient points of difference between standards adopted and provision of this specification and standards referred above shall be clearly brought out during detailed engineering along with the copies of such standards in English language.

6.6 Short Circuit Withstand Capability

6.6.1 Generator Step-Up Transformers

Complete three phase transformers shall be designed to be capable of withstanding without damage all stresses by symmetrical and asymmetrical short circuit currents in accordance with the relevant IEC Publication No. 60076-5.

The complete design and layout shall be subject to approval by the Purchaser.

Further Necessary and required details, if any, shall be furnished after award but before start of manufacturing.

6.7 Radio Interference and Noise Level

Transformers shall be designed with particular care to suppress at least the third and fifth harmonic voltages so as to minimise interference with communication circuits. Transformer noise level, when energised at normal voltage and frequency, with all the fans running shall be as per NEMA stipulations but not exceed 75 dB at one metre distance in either direction from transformer.

6.8 Performance Criteria and Guarantee

The transformers along with all accessories shall be capable of performing all intended duties and it is the responsibility of the Contractor to supply the equipment as per guaranteed technical particulars.

6.9 Evaluation and Rejection

The purchaser reserves the right to reject any transformer due to following reasons

- Total losses exceed the guaranteed figure by 10% or component losses exceed the guaranteed values by more than 15% individually. Impedance value exceeds the guaranteed value by + 10% or more.
- Oil or winding temperature rise exceeds the specified value by 5° C
- Transformer fails on impulse test.
- Transformer fails on power frequency voltage withstand test.
- Transformer is proved to have been manufactured not in accordance with the agreed specification.

The purchaser reserves the right to retain the rejected transformer and take it into service until the Contractor replaces (at no extra cost to the purchaser) the defective transformer by a new transformer.

Alternatively, the purchaser reserves the right to ask the Contractor to repair or replace the transformer within a reasonable period to the purchaser's satisfaction at no extra cost to the purchaser.

6.10 Integration with SCADA System

The transformers shall be suitable for co-ordination and integration with SCADA System and necessary contacts and/or ports for the purpose shall be provided.

6.11 Design and Construction

6.11.1 General

All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions without distortion or deterioration or the setting up of undue stresses which may impair suitability of the various parts for the work which they have to perform.

Similar parts, particularly removable ones, shall be interchangeable.

The Contractor shall connect tank and HV Neutral terminal to the earthing system.

The wheel locking arrangement shall be such that it does not necessitate the cutting of foundation bolts while removing the transformer for maintenance.

Tolerance in phase to phase spacing of high voltage and low voltage bushing and elevation of HV, LV terminals shall be as per relevant International Standards.

Padlocks along with duplicate keys as asked for various valves, marshalling box, fan control cabinet etc. shall be supplied by the Contractor.

Foundation bolts for wheel locking devices of transformer shall be supplied by the Contractor.

Pipes and pipe fittings, screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Steel bolts and nuts exposed to atmosphere shall be galvanized.

Nuts, bolts and pins used inside the transformers and tap changer compartments shall be provided with lock washers or locknuts.

Exposed parts shall not have pockets where water can collect.

Internal design of transformer shall ensure that air is not trapped in any location.

Facility shall be provided for lubrication of bearings and mechanisms.

Materials in contact with oil shall be such as not to contribute to the formation of acid in oil. Surface in contact with oil shall not be galvanised or cadmium plated.

Labels, indelibly marked, shall be provided for all identifiable accessories like relays, switches, fans, current transformers, etc.

All internal connections and fastenings shall be capable of operating under overloads and over-excitation, allowed as per specified standards without injury.

Transformer and accessories shall be designed to facilitate proper operation, inspection, maintenance and repairs.

No patching, plugging, shimming or other such means of overcoming defects; discrepancies or errors will be accepted.

6.11.2 Painting

The interior of all transformer tanks and other oil filled chambers and internal structural steel work shall be cleaned of all scale and rust by shot-blasting. These surfaces shall be painted with not less than two coats of heat resistant, oil insoluble and insulating varnish. 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 a glossy oil and weather resisting non fading, paint of shade No.631 as per IS 5.

Metal parts not accessible for painting shall be made of corrosion-resistant material.

Interior surfaces of mechanism chambers and marshalling kiosks shall receive three coats of paint after proper cleaning. The final coat shall be of a light coloured anti-corrosion paint.

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

In case finish paint chips off or crinkle during transit or installation, the Contractor shall arrange for repainting transformer at site at his cost. The paint for repainting shall be supplied by the Contractor.

6.11.3 Core

The cores shall be constructed from high grade Cold Rolled Non-Ageing Grain Oriented Silicon Steel Laminations.

The design of the magnetic circuit shall be such as to avoid static discharge, development of short circuit paths within itself or to the earthed clamping structure and the production of flux components at right angles to the plane of the laminations, which may cause local heating.

All parts of the core shall be of robust design capable of withstanding any shocks to which they may be subjected during lifting, transport installation and service.

Adequate lifting lugs shall be provided to enable the core and windings to be lifted.

Adequate provision shall be made to prevent movement of the core and winding relative to the tank during transport and installation or while in service.

The supporting framework of the cores shall be so designed as to avoid the presence of pockets, which would prevent complete emptying of the tank through the drain valve, or cause trapping of air during filling.

6.11.4 Windings

The low voltage winding shall be fully insulated as defined in IS: 2026 / IEC 60076. The neutral point of H.V. winding shall be insulated as per Standard.

The winding shall be designed to reduce to a minimum out of balance force in the transformer at all voltage ratios.

The insulation of transformer windings and connection shall be free from insulating composition liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inactive to transformer oil during service.

The stacks of windings shall receive adequate shrinkage treatment before final assembly. Adjustable devices shall be provided for taking up any possible shrinkage of coils in service.

The oil clamping arrangement and the finished dimensions of any oil ducts shall be such as will not impede the free circulation of oil through the ducts.

The winding conductor shall be of copper material. The conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperatures along the windings.

The windings and connections of all transformers shall be braced to withstand shocks, which may occur during transport, or due to switching short circuit and other transient conditions during service.

Coil clamping rings, if provided, shall be of steel with suitable insulating material. Axially laminated material other than bakelised paper shall not be used.

6.11.5 Bushings & Termination Arrangement

6.11.5.1 Bushings

The HV winding of each generator transformer shall terminate on 145 kV Oil bushings on the tank. LV side of the generator-transformer shall be connected to the 11 kV switchgear by XLPE cable. The bushing terminal shall be provided with connector for XLPE cables. The neutral for forming star point of HV windings inside the transformers shall be brought to a 145 kV neutral bushing on the tank. Test point shall be provided on condenser bushings for measurement of capacitance and Tan delta.

The Electrical characteristics of bushings shall be in accordance with relevant IEC standards / IS: 2099. Any stress shield shall be considered as an integral part of bushing assembly.

Current transformer, where required, shall be provided and the bushings shall be independently supported to ensure secure removal of bushings without disturbing the current transformer secondary terminals and connection.

6.11.5.2 Termination Arrangement

The step-up transformers shall be located in 132 kV switchyard. The switchyard is located at a distance of 30 m from powerhouse erection bay.

HV bushing of step-up transformer shall be connected to 145 kV switchgear located in 145 kV switchyard through overhead conductor.

11 kV cable box bushings of step-up transformer shall be connected through XLPE cable to 11 kV switchgear.

The neutral on generator transformers shall be formed external / internal to transformer depending upon whether transformer is single phase or three phase. The neutral so formed shall be suitable for connection to station ground bus. A neutral CT shall be housed on the neutral bushing. All necessary equipment for forming neutral shall be included in the scope.

6.11.6 Tank

The transformer tank and cover shall be fabricated from good commercial grade low carbon steel of tested quality and of adequate thickness. The tank and the cover shall be of welded construction. All seams, flanges, lifting lugs, braces and permanent parts attached to the tank shall be welded and, where practicable they shall be double welded. All joints, which may have to be opened from time to time in

the course of operation, shall be designed to permit their being made oil-tight reassembly easily. The tank shall be reinforced by stiffeners of structural steel for general rigidity. The tank cover shall be welded / bolted to the tank. The tank shall have sufficient strength to withstand, without permanent distortion, during

- Filling under vacuum
- Continuous internal gas pressure of 0.35 atmosphere with oil at operating level
- Short circuit forces
- Mechanical shocks during transportation.

At least two manholes with bolted cover shall be provided on the tank cover. Each manhole shall be of sufficient size to afford easy access to the lower end of the bushings, core & coil. Details of necessary facilities for handling the oil in such cases shall be listed in the tender.

All bolted connections to the tank shall be fitted with suitable oil tight gaskets, which shall give satisfactory service under the operating conditions. Special attention shall be given to methods of making the hot oil tight joints between the tank and the cover, between cover and bushings and all other outlets, to ensure that joints can be remade at site with ease as well. When compressible gaskets are used, means shall be provided to prevent over compression.

Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between cores and winding, and bottom of the tank for collection of any sediment.

Lifting eyes or lugs shall be provided on all parts of the transformer requiring independent handling during assembly or dismantling. The tank and the inspection covers shall also have suitable lifting arrangement. In addition, the transformer tank shall be provided with lifting lugs properly secured to the sides of the tank for lifting the transformers by crane as well as jacks.

The transformer tank, fittings and all accessories shall be designed to withstand seismic acceleration as specified in this specification. Special steps shall be taken to prevent mal-operation of Buchholz relay under such conditions.

The transformer tank shall be equipped with at least the following valves of appropriate size with standard screw connections for external piping:

- One upper oil filling valve(inlet) with vacuum attachment
- One drain valve (outlet) for complete drainage of the tank with padlocking arrangement.
- One filter valve shall be located at the top of the tank. The opening of this valve shall be baffled to prevent aeration of the oil and shall have padlock arrangement.
- One filter valve shall be located near the bottom of the tank.
- Two oil-sampling valves, one at top and one at bottom of main tank.
- All bolts and nuts used in connection with the tank and fittings shall be electro-galvanized.
- As far as possible the transformer tank and its accessories shall be designed without pockets where gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas off.

6.11.7 Under Carriage

The transformer tank shall be supported on strong structural steel base equipped with forged steel or cast steel.

6.11.8 Internal Earthing Arrangement

6.11.8.1 Earthing Of Core Clamping Structure

The top main core clamping structure shall be connected to the tank body by a copper strap. The bottom clamping structure shall be earthed by one or more of the following methods:

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

6.11.8.2 Earthing Of Magnetic Circuit

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

Magnetic circuits having an insulated sectional construction shall be provided with a separate link for each individual section. Where oil ducts or insulating barriers parallel to the plane of the lamination divide the magnetic circuit into two or more electrically separate parts, the ducts of barrage shall be bridged by tinned copper strip bridging pieces to maintain electrical continuity and the magnetic circuit shall not be regarded as being of sectional construction.

6.11.8.3 Earthing Terminal

Two earthing terminals capable of carrying the short circuit current of the transformer for four second shall be provided. Provision shall be made at position close to each of bottom two corners of the tank for bolting the earthing terminals to the tank to suit the local conditions.

6.11.8.4 Earthing Of Coil Clamping Rings

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

6.11.9 Tap Changing Equipment

Each transformer shall be provided with tank mounted, an off circuit tap changer for varying its effective ratio of transformation while the transformer is de-energized and without producing phase displacement. The tap changer shall be provided on the H.V. side and designed for bi-directional power flow. The tap changer shall be operated manually.

The off-circuit tap changer handle shall be provided with a locking arrangement along with tap position indicator, thus enabling the switch to be locked in position. A warning plate indicating that switch shall be operated only when the transformer is de-energized shall be fitted. Under condition of external short circuit, tap changing equipment shall be capable of carrying the same current as the transformer winding.

6.11.10 Conservator Vessel, Oil Gauge and Breather

Air bag type conservator shall be provided i.e. oil in conservator shall be separated from atmosphere by rubber bellow in the air balloon system. Each conservator vessel shall be fitted with two breathers in which silica gel is the de-hydrating agent and designed so that:

- The passage of air shall be such that it is first filtered through oil bath and then shall pass through silica gel with 100% redundancy through selector valves.
- The external atmosphere is not continuously in contact with the silica gel.
- The moisture absorption indicated by a change in colour of tinted crystals can be easily observed from distance.
- All breathers shall be mounted at approximately 1400 mm above ground level.

One number magnetic type oil gauge with low and high level alarm contacts shall be provided.

6.12 Transformer Cooling System

Generator transformers shall be ONAN cooled.

All cooling equipment shall be mounted on the transformer and supported in a manner such that no additional foundations are required. All cooling equipment shall include supports, mountings, automatic control equipment, conduits and wiring. Alarm relays shall be provided to indicate loss of AC power to each group.

The tank connections for the radiators shall be equipped with bolted flanges, and valves to allow for isolation of a radiator and the removal of any radiator without draining oil from the transformer or any other radiator. Radiator shall be provided with lifting eyes to permit lifting of the radiator by cranes or similar means. A drain valve with plug shall be provided in the bottom of each radiator. Vent holes with plugs shall be provided at the top of each radiator. Fan shall have galvanized steel guards. All fan motors shall be provided with a weatherproof flexible lead which is readily accessible for maintenance removal, and is fitted with a proper plug in connector.

All transformer Radiators shall have bolted flanged connections and pipe extensions to permit withdrawal of transformer tank without disturbing the radiators. Flexible joints shall be provided in the interconnecting pipes to facilitate erection and dismantling and reduce transfer of vibrations from tank to radiator. Blanking plates for each group of radiators shall be supplied.

The station auxiliary transformers shall be oil filled with ONAN cooling system. The oil flow inside and air outside the enclosure shall be natural.

6.13 Off Current Tap Changing Gear

The off circuit tap changer shall be operable by means of an operating handle brought out-side the tank and operable from ground level. It shall be equipped with an indicating device to show the tap in use and shall be provided with a locking arrangement to lock the switch in position. The tap changer contacts and connections shall be accessible through an access hole having a bolted gasketed cover.

Manual Control:

The cranking device for manual operation of the OCTC gear shall be removable and suitable for operation from the standing height above the floor level. The mechanism shall be complete with following:

- A mechanical tap position indicator.
- Mechanical stops to prevent over cranking of the mechanism beyond either of the extreme tap positions.

6.14 Cable Box and Cable Box Bushing

Cable boxes shall be suitable for operating outdoor and suitable for vertical arrangements of cables ascending to the box from below. Cable boxes for the transformers shall be with the disconnecting chambers so that the transformers with accessories can be removed for servicing or repair without disconnecting the cable connections.

Cable boxes shall be suitable for aluminium conductor, XLPE cables as specified. Compression glands and lugs shall be provided suitable for XLPE cables.

The design and construction of the cable box shall be such as not to permit the entry of moisture into the box. Supports for cable boxes shall be provided by the Contractor.

Suitable draining plug shall be provided with each cable box.

6.15 Marshalling Box

Sheet steel, vermin proof, well ventilated outdoor type, weather and dust proof marshalling box shall be provided with each transformer, to accommodate:

- Temperature indicators.
- Control and protection equipment for the cooling fan.
- Selector switches, contacts for annunciation, terminal blocks for CT connection etc.
- Terminal glands and gland plates for incoming and outgoing cables.

The temperature indicator shall be so mounted that the dials are not more than 1600 mm from the ground level and shall be visible without opening the marshalling box.

The box shall have on one side two hinges and second side locking arrangement, which can be duplicated. The box shall be tested for a quality conforming to minimum IP 55 class of protection of metal enclosure or better.

To prevent internal condensation, an approved type of metal-clad heater shall be provided, controlled by a suitable switch and thermostat.

6.16 Control Panel and Annunciation Schemes

Each generator transformer shall be provided with sufficient number of contacts for the following annunciation and alarms/trips on the initiating relay/device:

- Oil temperature high alarm
- Oil temperature very high trip
- Winding temperature high alarm
- Winding temperature very high trip
- Oil and gas relay alarm
- Oil and gas relay trip
- Low oil level alarm
- High oil level alarm
- AC supply fail
- Pressure relief device (PRD) operate

6.17 Piping, Valves and Flanges

The necessary piping, fittings and all types of valves shall be provided for connecting each transformer to the radiators. The oil piping shall be with machined flanged joints.

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

6.18 Fittings and Accessories

Each generator transformer shall be provided with the following fittings and accessories:

One dial type indicating thermometer for oil of robust pattern mounted on the side of the transformer at convenient height to read the temperature of the hottest part of oil. The Transformers shall be fitted with adjustable alarm and trip contacts. The oil temperature indicator shall be provided with anti-vibration mounting.

Two dial type winding hot spot, temperature indicators, one for each winding (H.V. and L.V. windings) of the transformer shall be provided. These shall be of the indicating type, responsive to the combination of top oil temperature and winding current, calibrated to follow the hottest spot temperature of the transformer winding. The winding temperature detectors in generator transformer shall operate a remote alarm in the event of hottest spot temperature reaching a predetermined value. The winding temperature indicator shall be provided with anti-vibration mounting.

- Repeater for winding temperature for remote indication shall be provided
- Pocket on tank cover for thermometer.

- One no. magnetic type oil gauge with low and high level alarm contacts shall be provided.
- Gas and oil actuated relay (Buchholz Relay) with alarm and trip contacts.
- 2 no. Silica gel breather (with 100% standby capacity) with oil seal and selector valves for selecting one and isolating the other for Generator Setup Transformer
- Pressure relief device
- Two earthing terminals along with bolt and spring washers
- Marshalling box for housing control equipment and terminal connections
- Complete wiring up to the marshalling box with PVC copper cables of 650/1000 V grade. Wiring shall be brought through designated steel conduit pipe properly clamped on the tank.
- Inspection cover for Generator Setup Transformer
- Oil valves in the main tank.
- Drain valve with padlocking arrangement
- Two sampling valves one at the top and other at the bottom for Generator Setup Transformer.
- Diagram and rating plate
- Lifting lugs for lifting the complete transformer assembly filled with oil.
- Lifting eyes or lugs on all parts of the transformer requiring independent handling during assembly and dismantling.
- ONAN accessories comprising of radiators drain & sampling device and air release device
- Bi-directional flange rollers with locking and bolting device
- Anti-earthquake clamping devices
- Under carriage
- Indicating, alarm, relay equipment shall have contacts suitable for operation with 220 V DC supply.

6.19 Quality Control and Assurance

The contractor has to supply the equipment of best quality. The contractor has to maintain quality control during manufacturing of equipment as per the approved quality assurance plans.

6.20 Drawings, Documents and Design Calculations

6.20.1 Drawings and Documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated under "General Technical Specification (GTS)". The drawings and documents shall include at least the following:

6.20.1.1 To be enclosed with the Bid

Drawings and data in addition to those mentioned elsewhere in the specification shall be submitted with each copy of the offer.

The tenderer shall furnish all the data/information especially guaranteed and other technical particulars called for.

6.20.1.2 To be submitted after award of contract

After award of the contract, a comprehensive list of drawings/documents planned to be submitted for reference/approval along with time schedule shall be furnished by the contractor for approval of the purchaser. All the drawings shall be prepared in AUTOCAD & same shall be in SCALE. The contractor shall supply 6 (six) copies of the following drawings, but not limited to, for purchaser's approval:

- Detailed quality assurance plan giving complete specification of the materials and specifications relating to inspection and testing of materials and finished components.
- General outline drawings showing crane lift for un-tanking, location and size of lifting lugs and eyes, bushing lifting dimensions, clearances between HV and LV terminals and ground, etc.
- Foundation plan showing loading on each wheel and jacking points with respect to centre-line of rail track in switchyard
- Schematic diagram showing the flow of oil and air in the cooling system as well as each limb and winding, longitudinal and cross-sectional view showing the duct sizes, radiator pipes, etc. for the transformers/radiator drawn to scale
- Large scale drawings of high and low tension windings of the transformers, showing the nature and arrangement of insulation and terminal connections
- Details of each type of bushing, bushing current transformers and terminal connections
- Details of neutral bushing terminal connection to ground mat
- Name plate drawing with terminal marking and connection diagram.
- Wheel locking arrangement
- Transportation dimension drawings.
- Magnetizing characteristic curves of current transformers
- Inter-connection diagram
- Over-fluxing withstand time characteristics of transformer
- Transfer surge calculations.
- Short circuit withstand calculations.
- Any drawing or information specifically required by the purchaser to check the suitability of design.

Subsequent to approval, the Contractor shall provide seven complete sets of final drawings, on of which shall be auto positive suitable for reproduction.

Erection, operation and maintenance manual (6 copies) shall be furnished by the manufacturer at least one month prior to the shipment of the first transformer. The manuals shall contain all the drawings and information required for erection, operation and maintenance of the transformers.

Descriptive literature and data (six copies) on transformer, windings, bushings, radiators, tap changing gear, temperature detectors, buchholz relay, instruments and controls, etc. shall also be supplied by the manufacturer along with the instruction manuals.

6.20.2 Design Calculations

The Contractor is required to submit the design calculation for following to the Engineer for approval during detail engineering.

- Temperature rise
- Size of cooling system
- Factors applied for altitude correction.

6.21 Tests

6.21.1 Type Tests

The purchaser may waive off carrying of all or any of the type tests if these have been carried out earlier on similar transformer as per IS: 2026 / IEC 60076. The contractor shall, therefore, submit test certificates of type tests conducted on similar type of transformers (same or higher MVA rating, same voltage class etc.), not older than five years from the date of bid opening, for approval by the purchaser. In case, the contractor is not able to submit test reports of type tests conducted on similar type of transformers in the last five years or in case the type test reports are not found to be meeting the specification / relevant standard requirements, then all such tests shall be conducted under the contract by the contractor free of cost to the purchaser and reports shall be submitted to the purchaser for approval.

If carrying of type tests is required by the Purchaser, One of the Generator Transformer shall be subjected to type and special tests as per relevant IEC / IS. The type tests shall also include following tests. The charges, if any, for carrying out the tests shall be indicated separately.

- Temperature rise test
- This test shall be carried out at lowest tap. Gas chromatographic tests on oil shall be carried out before and after of this test. The sampling shall be in accordance with IEC-60657. For evaluation of gas analysis in temperature rise test the procedure shall be as per IS-9434 and the result interpreted as per mutually agreed norms.
- Dielectric Tests as per IS: 2026
- Vacuum test on transformer tank
- The transformer tank designed for vacuum of 760 mm of mercury shall be tested at a maximum internal pressure of 3.33 KN/m sq. (25 torr) for one hour. The permanent deflection of the flat plates after the vacuum has been released shall not exceed the values specified below without affecting the performance of the transformer.

| Horizontal length of flat plate (in mm) | Permanent deflection (in mm) |
|---|------------------------------|
| Up to and including 750 | 5 |
| 751 to 1250 | 6.5 |
| 1251 to 1750 | 8 |
| 1751 to 2000 | 9.5 |
| 2001 to 2250 | 11 |
| 2251 to 2500 | 12.5 |
| 2501 to 3000 | 16 |
| Above 3000 | 19 |

- Pressure test on transformer tank:
- One Transformer tank along with its radiators, conservators and other fittings shall be subjected to pressure corresponding to twice the normal head of oil or to normal pressure plus 35 kN/m sq. whichever is lower. The applied pressure shall be 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 as indicated above.
- Type test on pressure relief device:
- The pressure relief device shall be subjected to increasing oil pressure. It shall operate before reaching the test pressure specified in the pressure test above. The device shall automatically seal-off after the excess pressure has been released.

6.21.2 Routine Tests

All the routine tests as per IEC 60076, IS 2026 as applicable shall be performed on each of the transformers.

Further the following additional tests shall be carried out on each transformer as Routine Test.

1. Oil leakage test on transformer tank

The transformer tank and oil filled compartments shall be tested for oil tightness by completely filling it with air/oil of viscosity not greater than that of insulating oil and applying a pressure equal to normal pressure plus 35 KN/m² measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which no leakage shall occur.

2. High voltage test on magnetic circuit/core

Each core assembly shall be tested by applying a voltage of 2000V AC for one minute between all bolts, side plates and structural steel works. Immediately prior to despatch of the transformer

from the manufacturer's works, magnetic circuit shall be pressure tested by applying 2000 V AC for one minute between core and the earth.

3. Tan delta measurement and capacitance of each winding to each (with all other windings earthed) and between all windings connected together to each.

6.21.3 Site Tests

- After erection at site, the following tests shall be carried out on each transformer:
- Measurement of insulation resistance.
- Measurement of voltage ratio and checking of polarity.
- Dielectric tests for the transformer oil.

6.21.4 Additional Tests

The purchaser reserves the right of carrying out other reasonable tests as provide in IS 2026 either before shipment or at site to ensure that the transformer complies with the requirements of the specifications.

6.21.5 Tests on Associated Equipment

Porcelain bushings, winding temperature indicating devices, dial type thermometers, buchholz relays, auxiliary motors and motor starting contactors, coolers, control devices, insulating oil and other associated equipment covered by the contract shall be tested by the contractor in accordance with relevant IS or IEC. The test certificates in respect of above equipment of similar capacity and design shall also be acceptable in lieu of type tests. Routine tests however shall be conducted in accordance with the relevant IS /IEC. If such equipment is purchased by the contractor on a sub-contract, he shall have them tested to comply with these requirements and the test certificates for both routine and type tests shall be furnished to the purchaser.

6.22 Packing

After completion of all the testing of transformers at shop and acceptance of the same by Purchaser, the transformers and their components shall be properly packed for shipment to site.

The transformers shall be transported without oil but with the tank filled positive pressure with nitrogen. A gas cylinder with suitable reducer connection and pressure gauge shall be supplied for replenishing the gas lost due to leakage.

All bushings and removable external accessories shall be dismantled and dispatched separately. All the openings thus resulting shall be sealed by means of temporary steel plates.

Impact recorder shall be supplied / installed by the contractor on each transformer to record the jerks during transit from the point of dispatch up to the site so as to ensure corrective action by the contractor, if any.

6.23 Installation and Commissioning

The contractor shall furnish all labour, tools, supplies, consumables and supports and all other provisions or materials necessary to assemble, erect, install, test and commission the equipment in a thorough workmanlike manner following the best modern practices. The equipment and all their components shall be placed with great care and shall be aligned correctly to provide an installation consistent with the close tolerances used in the erection of modern equipment. The proper elevations and centre lines to which equipment is to be set shall be established by the contractor.

All necessary materials and labour for performing all the site tests shall be provided by the contractor. All test equipment and instruments shall be furnished by the contractor and will remain the contractor's property after the fulfilment of all field tests.

All civil work required for foundation shall be carried by "other contractors". The contractor is required to submit all foundation drawings and supporting steels well in advance.

6.24 Drying and Filling of Oil

The transformers shall be dried out by an appropriate method at site. The contractor shall furnish complete details of method, tests etc. recommended for drying at site after site assembly.

Clear instructions shall be included in the maintenance manual regarding special precautionary measures, which shall be taken before applying the specified vacuum treatment. The maximum vacuum, which the complete transformer filled with oil, can safely withstand without any special precautionary measures, shall also be stated in the maintenance manual.

6.25 Field Tests

The contractor should furnish a complete outline of the proposed methods and procedures to be followed for the 16 MVA step up transformers including a list of equipment and instruments to be used, to the Purchaser at least 60 days before scheduled testing.

After installation, the transformers shall be field tested for functional tests of all control and protection equipment, tests of oil, Meggar value test of insulation as per relevant IEC standard.

The contractor shall prepare and hand over to the engineer details of all test results in a report in a mutually agreed format.

6.26 Spare Parts

The spare parts shall be as detailed below for supply.

| S. No. | Description | GSU trans | SST |
|--------|-----------------------------------|-----------|-------|
| 1 | HV bushings complete with gaskets | 2 nos. | 1 no. |

| | | | |
|---|--|--------|-------|
| 2 | Neutral bushings complete with gaskets | 1 no. | 1 no. |
| 3 | LV bushings complete with gaskets | 2 nos. | 1 no. |
| 4 | Gaskets for tank cover and fittings | 1 set | 1 set |
| 5 | Buchholz relays of each type in use | 1 no. | |
| 6 | Oil level indicator of each type in use | 1 no. | 1 no. |
| 7 | Pressure relief device of each type in use | 1 no. | 1 no. |

6.27 Special Tools

The Contractor shall propose the list of recommended special tools (other than those included under “Tools and Instruments” above) including their make and detailed specification as recommended by manufacturer(s) and to be accepted by the Purchaser.

6.28 Quality Assurance and Testing

The bidder shall submit the quality assurance plan along with bid for approval of the purchaser. The Contractor shall follow the quality assurance and testing requirements as per quality assurance plan approved by the purchaser.

6.29 Guaranteed and Technical Particulars

Guaranteed and Technical Particulars as called for in Vol. VI shall be furnished along with the bid. Bids lacking in this may be considered unresponsive. Particulars subject to guarantees shall be clearly marked

6.30 Completeness of Equipment

All fittings and accessories of the Generator and Auxiliary transformer and their associated auxiliary & ancillary equipment which may not have been specifically mentioned in these specifications, but are usually necessary for completion of the above equipment, shall be deemed to be covered by the specification; and shall be indicated and furnished by the supplier without any charges to the purchaser.

6.31 Deviation from Specifications

While the purchaser does not bind himself to accept any deviation, due consideration will be given to any special devices or equipment put forward by the supplier with a view to increase the efficiency of the equipment and minimize the maintenance cost of the equipment as a whole.

Should the supplier wish to depart from these specifications, he shall submit a complete and itemized list of such deviations, together with full particulars of the reasons for the deviations in a separate schedule with special reference to clause and paragraph nos. of this specification. Unless this is done and also the purchaser's concurrence in respect of such deviations is obtained in writing, the equipment offered shall be deemed to comply in every respect with these specifications.