SECTION – VIII

TECHNICAL SPECIFICATIONS OF TRANSFORMERS

8.1 SCOPE

The scope of work includes design, detailed engineering, manufacture of equipment, testing at works, assembly at manufacturer's works before dispatch, packing transportation, loading, unloading, supply and delivery F.O.R. destination, storage at site, erection, inspection, testing and commissioning of following equipment/system and works including preliminary acceptance tests and performance guarantee for Teepani Hydro Power Station:

i. 2 (two) Nos. 315 kVA 0.415/11 kV step up transformer

N.B. Both the transformers should be able to operate in parallel condition successfully as per relevant technical standards.

8.2 CODES AND STANDARDS

A list of applicable Codes of Practice and Standards has been given in Annexure-6/1. These shall be the latest editions including all applicable official amendments & revisions as on date of opening of bid.

8.3 SERVICE CONDITIONS

The equipment to be supplied under this specification will be installed outdoor at an altitude below 2000 meters and shall be suitable for satisfactory operation under the site conditions as described in Project Details.

8.4 PARTICULARS OF THE SYSTEM

The equipment shall be suitable for use on 0.415 kV and 11 kV 50 Hz, three phase effectively earthed neutral systems.

8.5 GENERATOR- TRANSFORMERS

8.5.1 TRANSFORMER RATINGS/CHARACTERISTICS

The ratings/characteristics of the transformers shall be as below:

Sl. No.	Particulars	Ratings/Characteristics
1.	Continuous MVA rating	315 KVA
2.	Type	Oil immersed
3.	Frequency	50 Hz $\pm$ 3%
4.	No. of Phases	Three
5.	Maximum voltage on H.V. side	12 kV (r.m.s.)
6.	Maximum voltage on L.V. side	0.440 kV (r.m.s.)
7.	Vector group	Y n d 11
8.	Connections i. H.V. windings	Star, neutral solidly earthed

	ii. L.V. windings	Delta
9.	Off-load taps on H.V. side (for H.V. variation)	(+) 2.5% to (-) 7.5% in steps of 2.5%
10.	Suitability of bushings	L.V. side suitable for cable box/connections. H.V. side : bushings for overhead conductor connection
11.	Type of cooling	ON

8.5.2 DESIGN AND CONSTRUCTION

i. The transformer shall be 3-phase, oil immersed with core type of construction, tank mounted radiators, and suitable for outdoor service as step-up transformer. Adequate Ceramic ball/spacers shall be provided in the core/winding for circulation of oil so as to ensure proper cooling. All apparatus shall be designed to ensure satisfactory operation under such sudden variations of load, frequency and voltage as may be met-with under system working conditions including those due to short circuits. To minimize the eddy current losses in the windings, CTC shall be used wherever required. Similarly, for minimizing the stray losses, magnetic shield in yoke, magnetic shunt in tank walls, bushing turrets, clamps, flitch plates etc. shall be provided, wherever required.

The design value of eddy current losses and stray losses shall be indicated by the manufacturer as a % of load losses.

ii. All materials used in the manufacture of the transformers shall conform to Codes and Standards as above.

iii. Design of all outdoor apparatus, including bushing insulators with their mountings shall ensure that no pockets be formed wherein collection of water can take place.

iv. Corresponding parts, which are liable for replacement, shall be interchangeable.

8.5.3 TEMPERATURE RISE, OVER-LOAD CAPACITY & CONTINUOUS RATING

i. Each transformer shall be capable of operating continuously on any tap at normal rating under service conditions given in Clause 6.5.1 without exceeding following temperature rises, over maximum ambient temperature of 45 deg. C:

a. 50 deg. C in winding (by resistance)
b. 45 deg. C in oil (by thermometer)
c. The temp. of hot spot in the winding not to exceed 90 deg. °C when calculated over max. annual weighted average temp. of 40 deg. C & 105 deg. C at worst ambient of 45 deg. C.

ii. Transformer shall be capable of delivering rated current at an applied voltage upto ± 10% of rated voltage without exceeding the temperature limit.

iii. The limits of temperature rise mentioned above and over-load capacity as per IEC-354 (1993) shall be satisfied by the manufacturer by carrying out the heat run test at the lowest negative tap. This test shall be carried out by feeding the following losses : -
(Total max. losses at 75 deg. C at highest current tap) x 1.1

iv. Safe over-load capacity of the transformer and the duration of over-load for ON cooling under maximum temperature conditions (Clause 6.5.3(i) above) without any damage to the winding or harmful effects on the insulation shall be as per IEC 354 and shall be clearly stated in the tender.

v. The transformers shall be operable without exceeding temperature rises, winding gradients and hot spot at any particular tapping at the rated MVA for ±10% of the voltage corresponding to that tapping.

8.5.4 TAP CHANGER

The range of transformer taps shall be as per serial no. 9 of table under clause 6.5.1. OFF - circuit tap changer having local manual control and with following features shall be provided:

i. Designed for sustained over current of not less than 150% of rated current of the winding.
ii. It shall not occupy any intermediate position between clearly marked tap positions.
iii. It shall be capable of repeated operation and withstanding S.C. forces.
iv. It shall have integral handle with pad-locking facility at every tap position.
v. The tap charger shall have tap position indicator.

8.5.5 CORE

i. Working flux density under rated voltage shall not exceed 1.55 Tesla at normal voltage, frequency and voltage ratio. Overfluxing shall be as per relevant standards.

ii. Tenders with higher flux density than specified shall not be considered.

iii. The core shall be built up with thin laminations of high grade, non-ageing, low loss, high permeability, cold rolled super grain oriented silicon steel, known as HIBIMOH or low loss CRGO silicon steel of maximum 0.27 mm or low lamination thickness specially suitable for transformer cores.

iv. The laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore original magnetic properties of material after cutting and punching operation.

The laminations shall be treated after cutting etc. to remove all burrs and checked during stage inspection. These shall be coated with baked enamel insulation coating. The insulation shall be inert to the action of hot transformer oil and be perfectly adhesive. Paper and varnish insulation shall not be accepted. Particulars of proposed insulation shall be stated in the tender.

v. The core shall be rigidly clamped and/or bolted to ensure adequate mechanical strength and to prevent vibrations during operation. The bolts used in the assembly of the core shall be suitably insulated and the clamping structure be so constructed that the eddy currents will be minimum.

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

vii. Number of steps in the limb and yoke shall be matching and dimensionally identical to minimize the effect of cross-fluxing and for better mechanical strength.

viii. The core shall be provided with lugs suitable for lifting complete core and coil assembly of transformer and be fixed in the tank so that its shifting will not occur when the transformer is moved or when a short circuit occurs.

ix. Every care shall be exercised in selection treatment and handling of core steel to ensure that the laminations are flat and that finally assembled core is free from distortions.

x. Supporting frame of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of the tank through the drain valve or cause trapping of air during filling.

xi. Oil ducts, where necessary, should be formed across the plane of the lamination and be given a suitable slope to assist oil circulation. The overall design of core and winding should ensure free flow of oil without obstruction.

xii. Frame work and clamping arrangement shall be earthed by connecting to the tank body through a copper strip. Yoke bolt area should be compensated if bolts are used for fastening of the core. Also, flitch plate area will not be counted in core area.

xiii. The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 kV (RMS) for one (1) minute.

xiv. Core and winding shall be capable of withstanding shocks during transport, installation, service etc. and adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

xv. All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

E.E. (E-M),
0/0 the CE, DHPD, Itanagar.

xvi. CRGO used shall be procured from reputed vendor.

xvii. The tenderer shall indicate the maximum flux density allowable continuously, as well as for time intervals of 1 minute and 5 secs. and the limit of flux density at which core material used by them saturates.

xviii. The name of the core material must be mentioned in the tender. The successful tenderer shall be required to furnish magnetization curves of the core material/design calculations and such other data/documents deemed fit by the purchaser for being satisfied that flux density is as desired.

xix. Purchaser may inspect the built-up core for verification of flux density for which all facilities shall be provided. Core may also be inspected during horizontal assembly, built up assembly.

NOTES:

i. The above flux density has been specified to meet with the over fluxing of the core due to temporary over voltage of the order of 31% for 1 min., 44% for 5 sec. that may appear in abnormal conditions such as those following sudden loss of large loads/ tripping of Generator-breaker.

ii. Yoke bolt area and flitch plate areas shall not be counted in the net core area, if these are provided for fastening of core.

iii. The design of limb and yoke shall be so coordinated that there is no cross fluxing at the joints.

8.5.6 WINDINGS

i. The conductor used for the winding shall consist of solid drawn high conductivity electrolytic grade copper free from scale and burrs.

ii. In case of copper strip, the corners shall be rounded-off to eliminate risk of injury to internal insulation during winding & other operations. No strip Conductor wound on edge should have width, exceeding six times its thickness.

iii. All permanent current carrying joints in the windings and leads shall be welded or brazed. Preference shall be given to a winding with a continuous conductor. The windings shall be pre-shrunk during manufacture so as to avoid any chances of any further shrinkage taking place during service. Provision shall be made so that it will be possible to take up this shrinkage by means of adjustable clamping screws and end rings in case of occurrence of shinkage.

iv. The voltage between adjacent coils shall be kept as low as consistent with the given design.

v. The windings shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the windings can be made readily without special equipment.

vi. The coils shall be supported between adjacent sections by insulation used in the assembly of the windings.

vii. The windings shall be arranged so as to ensure free circulation of oil and to reduce hot spots in the windings.

viii. All threaded connections shall be provided with locking facilities. All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used wherever practicable.

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

x. The windings shall be clamped securely in place so that they will not be displaced or deformed during short circuits. The assembled core and winding shall be dried and suitably impregnated before removal from the treating tanks.

xi. The insulation of the coils shall be treated suitably to develop full electrical strength of the windings and for this, hot oil vacuum impregnation process shall be used for improving the electrical and thermal properties of insulating paper.

xii. All materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise be adversely affected under the operating conditions.

xiii. The conductors shall preferably be CTC, transposed at sufficient intervals in order to minimize eddy current and equalize the distribution of current and temperature along the winding.

xiv. Windings shall preferably be made in dust proof condition.

xv. Tappings shall be so arranged as to preserve the magnetic balance of transformer at all voltage ratios. Tapping winding shall be provided separately from the main HV winding.

xvi. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

xvii. Inter-coil and inter-turn insulation shall be designed to ensure that di-electric stress is uniformly distributed through out the windings under all operating conditions.

xviii. The insulation of transformer windings and connections shall be free from insulating compound which are liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inert in transformer oil during service.

xix. The windings shall be braced to withstand shocks due to rough handling and forces due to short circuits, switching or other transients.

8.5.6.1 Reinforced Insulation

At each end of HV winding an electrostatic shield and/or cap & ring shall be provided so as to increase the ratio of the electrostatic capacity between turns as compared with the electrostatic capacity of the high voltage winding to earth and to the low voltage winding. HV winding shall preferably be interleaved.

8.5.6.2 Current Density

The design of the transformers shall ensure that the current density of the HV windings at the lowest tap does not exceed 250 A/cm^2, and that of the LV windings 200 A/cm^2.

8.5.7 INSULATION LEVEL

8.5.7.1 The insulating material to be used, shall be of class "F" as specified in the latest relevant standards.

8.5.7.2 The dielectric strength of winding insulation and of the bushings shall conform to values given in IS: 2026/1981 part-III amended upto date except for the changes made in this specification.

8.5.7.3 The impulse test and power frequency test voltage shall be as per the relevant IS/Standards followed.

8.5.7.4 Short Circuit Strength and Provision of Separate Tapping Coil for Regulation

Transformers shall be designed and constructed to withstand without damage the thermal and dynamic effects on external short circuits for 5 seconds under conditions specified in IS: 2026 (Part-I)- 1977.

The transformers shall be provided with separate tapping coil to limit the short circuit forces.

The position of the tapping coil shall be so arranged that at extreme negative tap, the percentage regulation is less than at normal tap.

The bidders shall submit test certificates of short circuit test, if already done on the offered design and rating. However, the thermal and dynamic ability to withstand short-circuit forces shall be demonstrated by calculations.

8.5.8 IMPORTANT TECHNICAL PARTICULARS

Important technical particulars of the transformers to be guaranteed by the tenderers shall be as per formats given in the concerned section.

8.5.9 TOLERANCES

Various tolerances on technical parameters shall be as under :-

i. Impedances:

Maximum tolerance allowed on impedances at all taps shall be as per IS:2026 (Latest edition).

ii. Over-Load

Transformers shall be tested for over-load conditions as specified in latest edition of IEC-354/1993 , which shall be read with IEC-76/1993.

iii. Weights

No negative tolerance shall be allowed on Weight of Copper, Weight of CRGO & Weight of Oil etc.

iv. Losses

No positive tolerance shall be allowed on guaranteed No load losses, Load Losses and Auxiliary Losses individually at rated voltage, current, principal tap & $75^{o}C$ temp.

v. Temperature Rise Test

No positive tolerance shall be allowed on Temperature Rise of Oil, Windings, Windings Temperature Gradients & Hot-Spot Temperature than the Guaranteed Values.

8.5.10 COOLING

Transformers shall have ON type of cooling.
Radiators shall be of pressed steel, tank mounted, bolted type. Bolted, gasketted and flanged connections shall be used for connecting the radiators to the tank.

Radiators shall be designed to withstand the pressure conditions specified for the tank and shall be designed so as to be accessible for cleaning and painting to prevent accumulation of water on the outer surfaces.

Radiator shall be provided with:

i. Top and bottom shut-off valves and blanking plates.
ii. Bottom drain plug, top filling plug and air release plug.
iii. Lifting lugs.

Valves and connections shall have following features:

i. Sluice type valves with hand wheels.
ii. Clear indication of open and closed positions.
iii. Provided with blanking plates and screwed plugs.

Insulating Oil

i. Sufficient insulating oil of NAPTHENIC TYPE (Made from NAPTHENIC CRUDE) conforming to BS: 148/IEC:296 class-I/IV shall be supplied for first filling of each transformer.

ii. An extra quantity of transformer oil equal to 10% of the total quantity of oil shall also be supplied.

iii. If the transformer is to be supplied gas filled, particular attention shall be paid to deliver the oil at site free from moisture and of uniform quality through out in non-returnable epoxy coated steel drums.

iv. The quantity of oil for first filling of each transformer shall be stated in tender along with manufacturer of the oil to be supplied.

v. Use of inhibitors in oil shall not be resorted to.

8.5.11 SUPPRESSION OF HARMONICS

The transformer shall be designed with particular attention to suppression of harmonic voltages especially the 3^{rd} and 5^{th} harmonics. Percentage of harmonics at normal voltage and at maximum system voltage shall be stated in the tender.

8.5.12 TRANSFORMER TANK

The transformer tank and cover shall be oil tight and fabricated from good commercial grade low carbon steel of adequate thickness. The weld procedure and performance shall be in line with ASME-BPV-9 /IS:2062. The tank and the cover shall be of welded construction. All seams shall be welded and where practicable they shall be double welded. The tank shall be designed and constructed for vacuum filling of oil and be capable of withstanding without leakage or distortion continuous internal gas pressure of 0.7 atmosphere with oil at operating level. The tank cover shall be bolted with the lower position of the tank and the transformer design shall make it possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.

Where the design of the tank is such that the bottom plate will be in direct contact with the surface of the foundations, the bottom plate thickness shall not be less than 20mm.

Man holes/inspection covers with welded flange and bolted covers shall be provided on the tank cover. The inspection covers shall be of sufficient size to afford easy access to the lower ends of bushings, terminals etc.

All bolted connections to the tank and connections between sections of the tank shall be provided with suitable flanges, with properly spaced bolts and suitable oil tight gasket which shall give satisfactory service under operating conditions.

The thickness of M.S plate for bottom, sides and top of the tank shall be adequate as per CBIP recommendations.

The main body including tap changing compartments, radiators and coolers shall be capable of withstanding full vacuum of 760mm of mercury when empty of oil.

The design of tank, its shape, proportions, weight of material and construction shall be such as to best facilitate oil circulation and to ensure against transmission or magnification of noise or vibration, which might be injurious or objectionable.

The transformer tank alongwith radiators and other accessories shall be tested for vacuum and pressure test as per CBIP recommendations.

Suitable guides shall be provided for positioning the various parts during assembly or dismantlement. Adequate space shall be provided between the cores and windings and the 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 dismantlement. In addition, the transformer tank shall be provided with lifting lugs and bosses properly secured to the sides of the tank for lifting the transformer by using hydraulic or screw jacks.

As far as possible, the transformer tank and its accessories shall be designed without pockets so that gasses may not collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main explosion pipe. The vent pipes shall have a minimum inside diameter of 15mm except for short branch pipes which may have 6mm minimum inside diameter.

The tank cover shall be provided with pockets one for mercury in glass thermometers and two pockets for the bulbs of oil and winding temperature indicators. Minimum depth of the thermometer pockets shall be 10" from top oil level. Protection shall be provided where necessary, for each capillary tube. The thermometer pockets shall be fitted with a captive screwed top to prevent ingress of water. The pockets shall be located in the position of maximum oil temperature at CMR and it shall be possible to remove the instrument bulbs without lowering the oil in the transformer tank.

Each transformer tank shall be fitted with the following valves/plugs with standard screw connections for external piping:

i. One filter-cum-oil drain valve with plug or blanking flange (size 80mm/ 100mm/ dia) and so placed as to completely drain the oil of the transformer.

ii. One no. top filter valve of size 50mm near the top of the tank diagonally opposite to filter-cum-drain valve.
iii. At least two nos. 15 mm/ dia air release plugs suitably located on top of cover.
iv. One pressure relief valve/device to operate at a pressure below the test pressure for the tank.
v. Suitable no. of jacking bolts shall be provided on tank cover and inspection covers.

The design of the tank, the lifting lugs and bosses shall be such that the complete transformer assembly filled with oil can be lifted with the use of these lugs without any damage or distortion.

All bolts and nuts used in connection with tank and fittings shall be galvanized/Zinc plated & passivated.

The tank shall be provided with suitable lugs for the purpose of grounding with a mild steel flat.

8.5.13 CONSERVATOR TANK

i. An oil conservator tank preferably air cell type complete with sump, filling hole and drain valve shall be mounted above the radiators and located so as not to obstruct taking of bare connections from the transformer terminals.
ii. The capacity of the conservator tank shall be adequate to meet the requirements of expansion of the total cold oil volume in the transformer and cooling equipment from minimum ambient temperature of minus 5 deg.C. to 115 deg.C.
iii. The minimum indicated oil level shall be, with the feed pipe from main tank cover, under not less than 15mm depth of oil and the indicated range of oil level shall be from minimum to maximum.
iv. One magnetic type oil level gauge with alarm contacts shall be mounted at a convenient height to be read from ground level. Prismatic oil level gague shall also be provided.
v. Oil level at 30 deg.C. shall be marked on the gauge.
vi. The conservator tank shall have one oil filling hole with cap at the top and drain valve of appropriate size at the bottom. A shut off valve shall be provided at the conservator to cut off supply to the transformer.
vii. The conservator tank will be designed to withstand strong wind pressure. Adequate stiffeners may be added, if necessary.
viii. Each conservator shall be fitted with a double compartment breather with oil seal in which silica gel is the dehydration agent and designed so that :-

a. The passage of air is through the silica gel.
b. The external atmosphere is not continuously in contact with the silica gal
c. The moisture absorption is indicated by change in colour of the tinned crystals and can be observed from distance.
d. All breathers shall be mounted at approximately 1400 mm above ground level.
e. The breather should be made of superior quality see-through material and should consist of two compartments placed in parallel.

f. The conservator shall be of air cell type, if possible, having provision for rubberized air cell so that air does not come in contact with oil in the conservator.

8.5.14 OFF-CIRCUIT TAP-CHANGER

Each transformer shall be provided with an off - circuit tap changing switch suitable for varying its effective ratio of transformation whilst the transformer is de-energized and without producing phase displacement. The off - circuit switch handle will 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.

8.5.15 ELECTRICAL CLEARANCES

The electrical clearance in air between live conducting parts and live conducting parts to each structure shall be as per the relevant IS/Standards followed.

8.5.16 FITTINGS AND ACCESSORIES

Each transformer shall be complete with the following fittings and accessories :

i. One 150 mm (6") dial type indicating thermometer (OTI) of robust pattern mounted on the side of the transformer at a convenient height to read the temperature in the hottest part of oil and fitted with alarm and trip contacts.
ii. One explosion vent on transformer tank cover.
iii. Inspection covers with jacking bolts in the top cover plates of the tank.
iv. One filter - cum - oil drain valve with plug or blanking flange size 80mm.
v. One filter valve at top of transformer tank size 50mm.
vi. One double float gas/oil surge detecting (Buchholz) relay in the pipe connecting the conservator with tank, complete with alarm/tripping contacts to detect accumulation of gas and sudden rise of oil pressure, complete with two shut - off valves on conservator side as well as tank side and a coupling to permit easy removal without lowering flanges/oil level in the main tank. The size of shut - off valve shall be 80mm.
vii. Two grounding terminals on breadth side of tank
viii. Skids and pulling eyes on both sides.
ix. One Marshalling box housing dial type thermometers for winding and oil temperature indicators.
x. Thermometer pockets for mercury in glass thermometer of minimum 25 cm depth from top level.
xi. A set of universal type bi-metallic multi-bolt double grooved conductor clamps for HV side capable of receiving single ACSR conductor (DOG) for bushing of 33 kV side of transformer.
xii. Suitable bi-metallic flexible connectors for neutral terminals.
xiii. One set of terminal bushings each for HV & LV winding
xiv. One set of Neutral bushing (s) with ring type CT of ratio 40/5, 5P15 15 VA for earth fault protection.
xv. Suitable size bi-directions wheels for rail gauge to suit existing tracks in both directions-4 Nos. along with locking and bolting devices.

E.E. (E-M),
0/0 the CE, DHPD, Itanagar.

xvi. The following plates, marked in English, shall be fixed to the transformer tank at about 1750mm above ground level:
   a. Rating plate bearing date as specified in IS: 2026/1977, it must contain insulation levels of various windings, impedance at normal & extreme taps short circuit duration, WTI ratio besides other information.
   b. Terminal marking plate showing the internal connections & voltage vector relationship of various windings in accordance with IS: 2026: 1977 (Latest Edition).
   c. Diagram plate showing the location and function of all valves and air release cocks or plugs.

xvii. Oil conservator (for main tank) complete as per 6.5.13.

xviii. One no. spare pocket on tank cover for thermometer.

xix. Off-circuit tap changer

xx. De-hydrating breather

xxi. Any other item, which is not included above but is essential for the satisfactory operation of the equipment.

8.5.17 ANTI-EARTHQUAKE CLAMPING DEVICE

A clamping device shall be provided for fixing the transformer to the foundations to prevent transformer movement during earthquake. The contractor shall supply necessary bolts for embedding in the concrete. The arrangement shall be such that the transformer can be fixed to or unfastened from these bolts as desired. The fixing of transformer to the foundation shall be designed to withstand seismic events to the extent that a static coefficient of 0.3g applied in the direction of least resistance to that of loading will not cause the transformer or clamping device as well as bolts to be over stressed.

8.5.18 EARTHING TERMINALS

Two earthing pads suitable for connecting 50x 8mm mild steel flat shall be provided at positions close to the two diagonally opposite bottom corner of tank. These grounding terminals shall be suitable for bolted connection. Two earthing thermals shall also be provided on marshalling box and any other equipment mounted separately.

8.5.19 UNDER CARRIAGE

The transformer shall be supported on a strong structural steel base equipped with forged steel or cast steel, single flanged, bi-directional wheels suitable for moving the transformer completely filled with oil. Jacking pads shall be provided to make it possible to change the direction of wheel through 90 degree when the transformer is lifted on jacks and permit movement of the transformer both in the longitudinal and transverse direction. Track gauge in both longitudinal and transverse direction shall match with the existing track at power house switchyard site. Means shall be provided for locking the swivel movement in position parallel to and at right angles to longitudinal axis of the tank.

Pulling eyes and skids shall be provided to facilitate moving of the transformer. These shall be suitably braced in the vertical direction to avoid bending when the pull has a vertical component.

8.5.20 BUSHING INSULATORS AND TERMINALS

i. Transformer shall be fitted with bushing insulators as follows :-
   a. HV Bushings: 12 kV
   b. LV Bushings: 0.440 kV

ii. Bushing shall be suitable for 25 times rated current for 5 seconds.

iii. Short time current withstand capability of bushing shall be 12.5 kA for 3 seconds for HV bushing and 40 kA for LV bushing.

iv. The electrical characteristics of bushings shall be in accordance with IS:3347 and IS:2029.

v. All bushings shall be equipped with suitable terminals of approved type and size and all external current carrying surfaces shall be adequately silver plated. All ends as well as all tappings on the windings shall be brought to terminals. Bushings which pass through the cover shall be removable without disturbing the transformer cover.

vi. The bushings shall have high factor of safety against leakage to ground and shall be so located as to provide adequate electrical clearances between bushings of various voltages and between bushings and grounded parts.

vii. Bushings of identical voltage shall be interchangeable. The insulating class of the high voltage neutral bushings shall be properly co-ordinated with the insulation class of neutral of the high voltage winding.

viii. Clamps and fittings shall be galvanised.

ix. Each bushing shall be so co-ordinated with the transformer insulation that all flash covers will occur outside the tank. All bushings shall have puncture strength greater than dry flash over value. Any stress shield shall be considered as integral part of bushing assembly. Only condenser type bushing shall be accepted.

x. Neutral bushings shall be provided as required for earthing of neutral point alongwith ring type of CT ratio 40/5, 5P15, 15 VA.

8.5.21 CENTRE OF GRAVITY

The center of gravity of the assembled transformer shall be low and as near the vertical center line as possible. The transformer shall be stable with or without oil., if the center of gravity is eccentric relative to track either with or without oil, its location shall be shown on the outline drawings.

8.5.22 JOINTS, GASKETS AND VALVES

i. All gasket used for making oil tight joints shall be of proven material such as granulated cork bonded with synthetic rubber. The material used should not deteriorate under the action of hot oil.

ii. All valves upto and including 100 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clockwise when facing the hand wheel. Means shall be provided for padlocking the valves in the open and closed position. Every valve shall be provided with flanges having machined faces. The drilling of valves flanges shall comply with the requirement of IS: 2026/IS: 3639.

8.5.23 CLEANING AND PAINTING

All corrodible parts and surfaces shall be of such material and shall be provided with such protective finish that no part of the installed equipment is injuriously affected by atmospheric conditions.

The whole of the exposed portion except bright parts shall be thoroughly cleaned by sand blasting and painted with two primary coats of approved rust resisting paint in dark admiralty grey colour. Inside surface shall be clean, smooth, free from voids and of best construction. The nature of coatings, provided inside, shall be specified and it shall be ensured that it does not react with transformer oil or deteriorates its electrical/chemical properties.

Some paint suitable for primary and secondary coats shall also be supplied to cover the damage to paint work which may be experienced during transportation.

8.5.24 MARSHALLING KIOSK

Made of sheet steel of minimum 3mm thickness, vermin proof, well ventilated and weather proof marshalling box of a suitable construction shall be provided for the transformer ancillary apparatus. Wiring up to marshalling box shall be with PVC/SWA, PVC copper cable 660/1100 volts grade IS certified/marked.

The marshalling box shall accommodate the following equipment: -

i. Temperature indicators.
ii. Terminal board and glands for incoming and out going cables.

The temperature indicators shall be so mounted that the dials are not more than 1600 mm from the ground level and the door(s) of the compartment(s) shall be provided with glass window of adequate size to prevent internal condensation. An approved type of metal clad heater with thermostat shall be provided, controlled by water tight single pole iron clad rotary switch mounted on outside of the box. The ventilation louvers, suitably padded with felt, shall also be provided.

All outgoing connections from the transformer viz.: Buchholz relay, temperature indicators, level indicators, etc. shall be wired to marshalling kiosk.

All incoming cables shall enter the kiosk from the bottom and the gland plate shall not be less than 450 mm from the base of the box. The gland plate and associated compartments shall be sealed in suitable manner to prevent the ingress of moisture from the cable trench.

8.5.25 CONTROL CONNECTION, INSTRUMENT WIRING, TERMINAL BOARDS & FUSES

All wiring connections, terminal boards, fuses and lines shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation. There shall be no possibility of oil entering connection boxes used for cables and wiring. When 415 volts connections are taken through junction boxes of marshalling boxes, they shall be adequately screened and 415 volts danger notice must be affixed to the outside of junction boxes or marshalling boxes. All wiring shall be with stranded copper of 1100 volts

grade and 4.00 sq. mm for CT leads and not less then 2.5 Sq.mm for other connections. All wiring cables shall be ISI- marked/certified and in accordance with the relevant ISS.

All wires on panels and all multicore cables shall have ferrules bearing same number at both ends. Same ferrule numbers shall not be used on wires in different circuits, on the same panels. Ferrules shall be of white insulating material and be provided with glossy finish to prevent adhesion of dirt. They shall be clearly and durably marked in black and shall not be effected by dampness or oil. Wiring shall, in general be accommodated on sides of the box and wires for each circuit shall be separately grouped.

Back of panel wiring shall be arranged so that access to the connecting stems of relays and other apparatus is not impeded. All the cables and capillary types of OTI and WTI etc are to be wired properly on cable trays with the help of suitable cleats upto the marshalling box. The cable trays shall be kept minimum 100 mm away from the tank body to avoid excessive heating of cables/wires.

Wires shall not be joined or tied between terminal points. Wherever possible, all circuits in which the voltage exceeds 125 volts, shall be kept physically separated from the remaining wiring.

The function of each circuit shall be marked on the associated terminal boards.

Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of copper wire.

No live metal part shall be exposed at the back of terminals boards.

All fuses shall be of cartridge type and links shall be labelled.

All wiring diagrams for control panels shall preferably be drawn as viewed from the back.

The overall design of wiring shall be such that various wires and ends of the same wire can be traced easily and there is convenience to access the terminations and ferrule number shall be readable with convenience.

8.5.26 DRAWINGS

The tenderer shall submit with his tender, one set of dimensional drawings of the equipment offered, alongwith illustrated and descriptive literature for scrutiny.

The successful bidder after the award of the contract, shall supply four copies of the following drawings documents within 30 days after the receipt of purchase order, which will describe the equipment in detail for approval by the Purchaser.

i. Detailed outline General Arrangement drawing showing plan, front elevation, side elevation with all fittings and accessories etc. Following information must be specifically included on this drawing:

b. Make of transformer oil.

c. Electrical clearances, minimum as well as actual.
d. The no. of radiator elements, width, thickness of sheet & height of each radiator.
e. A sketch showing detailed procedure for dismantling.
f. Thickness of transformer tank bottom, side & top plates.
g. Type, shade, shade no. and thickness of transformer paints.
h. Roller, rail gauge sketch.
i. Weight of oil; Bare copper windings, core, un-tanking mass, transportation mass and dimension etc.

ii. Detailed drawing of bushing, showing plan & elevation, terminal details, mounting details, make and type, number, incorporating electrical characteristics, description of various parts, total creepage/protected creepage distance, weight of oil, total weight of bushing, dimensions, short time rating etc.
iii. Transportation sketch showing dimensions and weights of the heaviest package and the shipping arrangements of the transformer.
iv. Rating and diagram plate.

NOTE: Bushing CT's for WTI's are to be provided on HV side.

v. Detailed structural drawings for the transformer tank, under carriage, conservator, radiators, supporting structures for cooling fans etc.
vi. Dimensional drawings of multi bolt bimetallic connectors for line ends and flexible connectors for the neutral ends.
vii. Roller Stopper arrangement drawing.

8.5.27 ADDITIONAL DRAWINGS

Following drawings shall be supplied for reference and record in addition to the above listed drawings.

i. Large scale drawing of high and low voltage windings of transformer showing the nature and arrangement of insulation and terminal end connections.
ii. Drawing showing sectional view of the HV and LV windings when viewed from top.
iii. Detailed drawings of conservator and pressure relief device (explosion vent) mounted in position.
iv. Foundation plan of the transformer including auxiliary equipment.
v. Any other drawing considered necessary by the Purchaser.
vi. A schedule showing the requirement of set of spare gaskets.

8.5.28 INSTRUCTION MANUALS

The successful tenderer shall be required to supply 6 (six) sets of instruction manuals per transformer, each properly bound in hard cover.. Each set shall consist of the following:-

i. All the approved drawings listed above..
ii. Erection, Operation & Maintenance manual for transformer and pamphlets for all spare parts e.g. OIL, WTI, Off- load tap-changer Buchholz relay, Silica-gel breather / Pressure relief valve.
iii. Instructions for dehydration, if any.

E.E. (E-M),
0/0 the CE, DHPD, Itanagar.

iv. Precautions prior to vacuum application, if any.
v. Any other information/data/documents/instructions considered necessary by the manufacturer for efficient functioning of the transformer.

8.5.29 GUARANTEED DATA AND OTHER PARTICULARS

Guaranteed data and other technical particulars of the transformers offered shall be furnished by the tenderer in accordance with format provided in section-XIII of this specification for all the transformers.

8.5.30 PLACE OF MANUFACTURE, TESTING AND INSPECTION

The tenderer shall state in his tender, the place (s) of manufacture, testing and inspection of various portions of the work included in the tender. The place of manufacturing shall not be allowed to be changed at a later stage.

The purchaser or his duly authorized representative shall have access to the manufacturer's works at any time during working hours for the purpose of inspecting the manufacture & testing of materials, equipment and completed plant and the supplier shall provide necessary facilities for inspection.

8.5.31 INSPECTION AND TESTING

The successful tenderer shall submit complete set of drawings as already brought out in this specification within 30 days from the receipt of purchase order. The suppliers will furnish schedule of manufacturing of the transformer alongwith the drawing.

Purchaser can inspect the raw material, manufacturing process at sub-supplier's works for which advance intimation of manufacturing activities shall be given.

i. Radiators

Radiators shall be routine/type tested at supplier works as per relevant standards.

ii. Routine Testing

All routine tests shall be carried out on each transformer as per IS- 2026/ IEC-76 & IEC- 354

iii. Type testing

Following type tests and T/F withstand capacity beyond name plate as per IEC-354 shall be carried out as per IEC-76/IEC- 354 & IS- 2026 on the transformers :-

j. Temp. Rise Test with 2x50% radiators only.
ii. Impulse Voltage withstand test on all the three phases with chopped impulse.

8.5.32 FOUNDATIONS AND FIXINGS

All plant and equipment shall be provided with a complete set of foundation bolts, washers, nuts, plates and other fixtures as may be required and these shall be supplied by the supplier. These fittings shall be fixed by the purchaser in the foundations, unless otherwise specified.

All foundations, bolts, fixtures etc. shall be supplied as soon as possible after the contract drawings have been approved.

8.5.33 PACKING, DESPATCH AND DELIVERY

The supplier shall be responsible for suitable packing of all equipment and marking of the consignments so as to avoid any damage during transit, storage and to ensure correct dispatch to the destination. Damages to equipment/material in transit due to improper packing shall be to supplier's account. All parts requiring protection from moisture shall be especially packed to prevent ingress of moisture. No parts of any kind shall be packed inside other larger parts. Heavy parts shall be so mounted that there is no difficulty in attaching slings etc. for unloading at destination.

All parts shall be adequately marked to facilitate field erection. Boxes and crates shall be marked with contract number and shall have packing list enclosed, showing the parts contained therein.

In case the transformers are despatched gas filled and oil for first filling is despatched separately, sufficient quantity of gas in NON RETURANABLE Cylinders shall be supplied to maintain the pressure of the gas in the tank at site before it is filled with oil.

8.5.34 TOOLS

The transformers shall be supplied with a set of special tools, if considered necessary for assembling and dismantling of transformer. The details of the tools etc. included in the offer shall be given.

8.5.35 SPARES

All the spare parts of the equipments shall be interchangeable and shall be of same material and workmanship as the corresponding parts furnished with main equipment. Unit prices of any additional spares considered necessary may be indicated separately. The F.O.R. destination prices shall be mentioned clearly against each item given above. Further, voltage & current rating of each spare bushing should be clearly indicated and should be same as that of bushing provided on the transformers.

8.5.36 DRYING-OUT AND ERECTION

The transformer shall be dried-out by an appropriate method at the manufacturer's works and so arranged for transportation and storage that it may be put into service without further drying out at site. For any subsequent drying out which may be necessary at site the manufacturer shall give details of the method recommended for using the same.

The transformer shall be designed to withstand pressure and vacuum tests as specified by CBIP specification for power and distribution transformers :-

i. Vacuum as per CBIP manual to be applied to tank and cooling equipment when empty of oil.
ii. Pressure of 1 kg/cm^2 mercury applied to tank and cooling equipment when empty of oil.

E.E. (E-M),
0/0 the CE, DHPD, Itanagar.

iii. Pressure of 0.5 kg/cm^2 to be applied at conservator on fully assembled transformer when full of oil.

Clear instructions shall be given in the maintenance manual regarding special precautionary measures e.g. stucking up of tap changer barrier or tank cover which must be taken before applying the specified vacuum treatments. The maximum vacuum which the complete transformer filled with oil, can safely withstand without any special precautionary measures being taken shall also be stated in the maintenance manual.

The bushings shall be capable of withstanding vacuum operation when drying out the transformer.

E.E. (E-M),
0/0 the CE, DHPD, Itanagar.

Annexure-6/1

STANDARDS, SPECIFICATIONS AND CODES OF PRACTICE

1. POWER TRANSFORMERS

IS:	1367	Hot dip galvanized cooling on threaded fasteners.
IS:	1866	Code of practice for maintenance of insulating oil.
IS:	2026	Specification for Power Transformers
IS:	2705	Current transformers
IS:	3347	Dimensions of porcelain transformer bushings for use in lightly Polluted Atmospheres
IS:	3637	Gas operated relays
IS:	3639	Fitting & accessories for Power Transformers
IS:	6600	Guide for loading of oil immersed transformers
IS:	9434	Guide for sampling and analysis of free and dissolved gas in oil filled Atmosphere.
IS:	10028	Code of practice for selection, installation and maintenance of transformer
IS:	12371	Technical requirements for single action telescopic tipping cylinders for agriculture trailers
IEEE:	32	IEEE standard requirement terminology and test procedure for neutral Grounding device.
CBIP:		Manual of Transformer.

Equipment complying with other internationally accepted standards such as IEEE, IEC, BS, USA, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case the Bidder shall clearly indicate:

i. The standards adopted,
ii. The bidder shall clearly bring out salient features for comparison with the standards listed under serial 1 above.
iii. Furnish a copy (in English) of the relevant standards adopted (along with the latest revision of standard and copies of all official amendments and revisions in force as on date of opening of bid).

E.E. (E-M),
0/0 the CE, DHPD, Itanagar.