TRANSFORMERS

1.0 GENERAL

1.1 This section specifies the technical requirements, constructional features, testing requirements and painting procedure for various types of power & distribution transformers.

1.2 The equipment to be supplied against this specification shall conform to relevant IS specification, mentioned here in below. Material conforming to other internationally accepted standards, which ensure equal or higher quality than the standards mentioned above would also be acceptable. In case the Bidders wish to offer material conforming to the other standards, salient points of difference between the standards adopted and the specific standards shall be clearly brought out in relevant schedule. Four copies of such standards with authentic English translations shall be furnished along with the offer.

1.3 All deviations from this specification shall be separately listed under the requisite schedules, in the absence of which it will be presumed that all the provisions of the specification are complied with by the bidder.

1.4 ALTITUDE FACTOR

Specific technical requirements given at relevant sections are for the equipment to be installed at an altitude below 1000 meter. If the equipment is to be installed in altitude above 1000 meter, necessary correction factors as given in the Indian Standard for oil temperature rise, insulation level etc. shall be applied to the Standard Technical Parameters given above.

1.5 SERVICE CONDITIONS

The Transformers to be supplied against this Specifications shall be suitable for satisfactory continuous operation under the climatic conditions indicated in the General Technical Requirements (GTR), which are to be guaranteed

1.0 POWER TRANSFORMERS

1.1 INTRODUCTION

This chapter covers specification of Power Transformers, Station Transformer and Distribution Transformers complete with all accessories and fittings as specified herein.

1.2 SPECIFIC TECHNICAL REQUIREMENTS

1.	Rated MVA (ONAN rating)	2.5MVA, 3.15 MVA , 5 MVA, 7.5 MVA & 10 MVA
2.	No. of Phases	3
3.	Type of Installation	Outdoor
4.	Frequency	50 Hz
5.	Cooling medium	Insulating Oil
6.	Rated voltage – a) High voltage winding b) Low voltage winding	 33kV 11kV
7.	Highest continuous system voltage a) HV Side b) LV side	 36kV 12kV
8.	Type of tap changer	Off Load Tap Changer/ On Load Tap Changer, as applicable
9.	Range of tapings	+5% to –10% in steps of 2.5% each on HV winding
10.	Neutral terminal to be brought out	On LV Side only
11(a).	**Impedance** on rated MVA base at 75 ^{0}C **(5 MVA)**	**7.15%** with tolerance limits as per IS.
11(b).	**Impedance** on rated MVA base at 75 ^{0}C **(2.5MVA, 3.15 MVA)**	**6.25%** with tolerance limits as per IS.

11(c).	**Impedance** on rated MVA base at 75 ^{0}C **(7.5 MVA & 10 MVA)**	**8.35%** with tolerance limits as per IS.
12.	Type of insulation and insulation level	Uniform both HV & LV
13.	One minute power frequency withstand test voltage (kVrms)	33kV: 70; 11kV: 28
14.	Impulse withstand test voltage (kV peak)	170; 75
15.	Winding connection	
	a) HV Side	Delta
	b) LV Side	Star
16.	Winding material	Electrolytic Copper
17.	Vector group	Dyn 11
18.	Type of cooling	ONAN
19.	Neutral earthing	LV neutral shall be solidly earthed
20	Current Density	Maximum 2.5 Amp/sq.mm.
21	Flux Density	**Maximum 1.6 Tesla at Normal Voltage and frequency**
22	Overload capacity	As per IS 6600.

1.2.1. **TEMPERATURE RISE:** The transformer shall be capable of operating continuously at its normal rating without exceeding the temperature rise limits as specified below:

i)	Temperature rise of top oil (Measured by Thermometer)	=	40 ^{0}C
ii)	Temperature rise of winding (Measured by resistance)	=	45 ^{0}C

The rise in temperature of top oil and winding given above shall be applicable over an ambient of 50 ^{o}C in accordance with IS 2026.

1.2.2. **NOISE LEVEL**

Every care shall be taken to ensure the design & manufacture of transformers shall be such as to reduce noise and vibration to the level of that obtained in good modern practise. The manufacturers should ensure that the Noise level shall be as per NEMA values.

1.3 PERFORMANCE

1.3.1. The performance of the transformer shall be measured on the following aspects.

i) Transformer shall be capable of withstanding short circuit at the terminals.

ii) Transformer shall be capable of withstanding thermal and mechanical stress caused by any symmetrical and asymmetrical faults on any winding.

iii) The transformer shall be capable of being operated without danger on any tapping at the rated KVA with voltage variation of ± 10% corresponding to the voltage of the tapping.

iv) The maximum flux density in any part of the cores and yokes at normal voltage and frequency shall be such that the flux density on any tap position with +12.5% voltage variations and –5% frequency variations shall not exceed 1.9 Tesla

v) The transformer shall be designed and constructed so as not to cause any undesirable interference in radio or communication circuits.

1.4 DRAWINGS/DOCUMENTS

1.4.1. Following drawings/documents incorporating name of project and transformer rating shall be submitted for approval.

i) Detailed Overall general outline drawing showing front and side elevations and plan of the transformer and all accessories including radiators and external features with details of dimensions, spacing of wheels in either direction of motion, net weights and shipping weights, crane lift for un-tanking, bushing lifting height, clearances between HV and LV terminals and ground, quantity of insulating oil etc.

ii) Foundation plan showing loading on each wheel and jacking points with respect to centre line of transformer.

iii) GA drawings/details of bushing.

iv) Name plate drawing with terminal marking and connection diagrams.

v) Wheel locking arrangement drawing.

vi) Transportation dimensions drawings.

vii) GA drawing of marshalling box.

viii) Control scheme/wiring diagram of marshalling box.

ix) Technical leaflets of major components and fittings.

x) Oil temperature indicator and winding temperature indicator showing.

xi) Completed technical data sheets.

xii) Bi- metallic terminal connectors.

xiii) Instructions Manuals.

1.5 MISCELLANEOUS

1.5.1. CODES & STANDARDS

i) GENERAL

ii) The equipment, materials and service covered by this specification shall conform to the latest applicable provision of the following standards:

Sr no	Reference Standards / Codes	Description
1	IS:2026 (Part I to IV)	Power Transformer
2	IS:2099	High Voltage Porcelain Bushings
3	IS:335	Insulating Oil For Transformers, Switchgears
4	IS:3347/ 8603	Dimensions For Porcelain Transformer Bushings

Sr no	Reference Standards / Codes	Description
5	IS:5	Colour For Ready Mixed Paints
6	IS:13947	Degree Of Protection Of Enclosures
7	IS:3639	Fittings And Accessories For Power Transformers
8	IS: 3637	Gas Operated Relays
9	IS: 6600	Guide For Loading Of Oil Immersed Transformers
10	IS: 5561	Electric Power Connectors
11	C.B.I.P. Publication	Manual On Transformers
12	IS: 6005	Code Of Practice For Phosphating Of Iron And Steel

1.6 CONSTRUCTIONAL FEATURES

1.6.1. TANK

The Transformer tank and cover shall be fabricated from high grade low carbon steel of tested quality of adequate thickness. The tank and the cover shall be of welded construction. All welds shall be stress relieved. Stiffener shall be provided for general rigidity. There will be no internal pockets, where gas or air can accumulate. Tank surface shall be designed to prevent retention of water.

1.6.2. Tank shall be designed to permit lifting by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.

1.6.3. All beams, flanges, lifting lugs, braces and permanent parts attached to the tank, shall be welded and where practicable, they shall be double welded. All pipes, radiators, stiffners, welded to the tank shall be welded externally.

1.6.4. The main tank body of the transformer, excluding tap changing compartments and radiators, shall be tested for vacuum and pressure withstand test as per procedure given in Annexure-III. .

1.6.5. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer. Special attention shall be given to the methods of making the hot oil-tight joints between the tank and the cover as also between the tank cover and the bushings and all outlets to ensure that the joint can be remade satisfactorily and with ease, with the help of semi-skilled labour. Where compressible gaskets are used, suitable arrangement shall be provided to prevent over-compression.

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

1.6.7. The tank shall withstand

i) Mechanical shock during lifting, jacking & transportation **with oil filled**.
ii) Vacuum
iii) Internal pressure which may developed during service

1.7 TANK COVER

1.7.1. The transformer top shall be provided with a detachable tank cover with bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

1.7.2. Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.

1.7.3. Pockets shall be provided for bulbs of OTI & WTI. Air and Oil tightness shall be ensured for the same.

1.7.4. The bolted openings shall be fitted with weather proof hot oil resistant neoprene gasket for complete tightness.

1.8 UNDER CARRIAGE

1.8.1. The transformer tank shall be supported on steel structure with detachable plain flanged bidirectional rollers completely filled with oil. Suitable channels for movement of roller with transformer shall be spaced accordingly. Rollers wheels shall be provided with suitable rollers bearings, which will resist rust and corrosion and shall be equipped with fittings for lubrication. It shall be possible to swivel the wheels in two directions, at right angle to or parallel to the main axis of the transformers.

1.8.2. Jacking pads shall be provided on the transformer. It shall be possible to change the direction of the wheels through 90 degree when the transformer is lifted on jacks to permit movement of the transformer both in longitudinal and transverse directions.

1.9 CORE

1.9.1. Stage level inspection for core construction shall be carried out by the owner.

1.9.2. The core shall be constructed either from high grade, non-aging Cold Rolled Grain Oriented (CRGO) silicon steel laminations conforming to grade M4 or better. The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall be such that the flux density with + 12.5 % voltage variation from rated voltage or frequency variation of -5% shall not exceed 1.9 Tesla. The bidder shall provide saturation curve of the core material proposed to be used.

1.9.3. The bidder should offer the core for inspection and approval by the purchaser during the manufacturing stage. Bidder's call notice for the purpose should be accompanied with the following documents as applicable as a proof towards use of prime core material:

i) Invoice of the supplier
ii) Mills test certificate
iii) Packing list
iv) Bill of lading
v) Bill of entry certificate to customs

Core material shall be directly procured either from the manufacturer or through their accredited marketing organization of repute and not through any agent.

1.9.4. The laminations shall be free of all burrs and sharp projections. Each sheet shall have an insulating coating resistant to mechanical pressure and the action of hot oil.

1.9.5. Use of seconds CRGO Steel for core construction is strictly prohibited.

1.9.6. The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation. The core clamping structure shall be designed to minimize eddy current loss. The framework and clamping arrangements shall be securely earthed. The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength. The core insulation should withstand power frequency voltage of 2 kV for one minute.

1.9.7. The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angle to the plane of the lamination, which may cause local heating. Clamping of core must be sufficiently rigid to have least possible air gap to minimise core loss and noise generation. 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.

1.9.8. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The core and coil assembly shall be so fixed in the tank that shifting will not occur during transport or short circuits and the assembly shall withstand these with ease.

1.9.9. **All steel sections for clamping of core are to be sand blasted after cutting, drilling and welding**

1.10 INTERNAL EARTHING

1.10.1. All internal non alive metal parts of the transformer, with the exception of individual laminations, core bolts and their individual clamping plates shall be earthed by connecting to tank by copper strip.

1.10.2. The magnetic circuit shall be connected to the clamping structure at one point only and this shall be brought out of the top cover of the transformer tank through a suitably rated insulator. A disconnecting link shall be provided on transformer tank to facilitate disconnections from ground for IR measurement purpose.

1.11 WINDING

1.11.1. Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Winding shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. Winding and connections shall be braced to withstand shocks during transport, switching or short circuit.

1.11.2. Terminals of all windings shall be brought out of the tank through bushings for external connections. The leads used shall be rigidly supported.

1.11.3. All material used in the insulation and assembly of the winding shall be insoluble, non catalytic and chemically inactive and shall not soften, ooze out, shrink or collapse in hot transformer oil during service or otherwise be adversely effected under operating conditions. The end turn of each layer shall be properly and fully covered with insulation and rigidly supported to avoid interlayer flashover or injury from vibration.

1.11.4. The completed core and coil assembly shall be dried in vacuum at not more than 0.5mm of mercury absolute pressure and shall be immediately impregnated with oil after the drying process to ensure the elimination of air and moisture within the insulation.

1.11.5. The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the winding can be made readily without special equipment. The coils shall have high dielectric strength.

1.11.6. Coils shall be made of continuous smooth high grade electrolytic copper conductor, shaped and braced to provide for expansion and contraction due to temperature changes.

1.11.7. Adequate barriers shall be provided between coils and core and between high and low voltage coil. End turns shall have additional protection against abnormal line disturbances.

1.11.8. The assembly shall be designed to ensure free circulation of oil.

1.12 INSULATING OIL

1.12.1. The insulating oil shall conform to IS: 335. No inhibitors shall be used in the oil.

1.12.2. The Transformer shall be supplied completely with first filling of oil. The insulating oil shall be new and of reputed make complying with the requirements of IS 335 with latest version thereof or BS 148..

1.12.3. The design and materials used in the construction of the transformer shall be such as to reduce the risk of the development of acidity in the oil.

1.12.4. The contractor shall warrant that oil furnished is in accordance with the following specifications.

S. No	Characteristic	Requirement	Method of Test
1	Appearance	The oil shall be clear & transparent & free from suspended matter or Sediment	A representative sample of oil shall be examined in a 100 mm thick layer at ambient temp.
2	Dielectric strength Break Down (voltage) Min.	**More** than 72.5 kV	IS: 6792
3	Water content Max:	Less than 25 ppm	IS: 2362

All other characteristic shall be as per IS 335

1.13 VALVES

1.13.1. Valves shall be of forged carbon steel or Gun metal upto 50 mm. They shall be opened by turning counter clockwise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.

1.13.2. Each valve shall be provided with an indicator to show the open and closed positions and shall be provided with facility for padlocking in either open or closed position. All valves except screwed valves shall be provided with flanges having machined faced drilled to suit the applicable requirements. Oil tight blanking plates shall be provided for each connection for use when any radiator is detached and for all valves opening to atmosphere. If any

special radiator valve tools are required, the Contractor shall supply the same.

1.13.3. Each transformer shall be provided with following valves on the tank:

i) Drain valve so located as to completely drain the tank.
ii) Two filter valves.
iii) Oil sampling valves.
iv) Air release plug.
v) Valves between radiators and tank.

Filter valves shall be suitable for applying vacuum.

1.14 ACCESSORIES

1.14.1. BUSHING HV & LV

Porcelain Bushing on top of tank shall be provided on HV side. For LV side porcelain bushings, the connections will be done with armoured XLPE cable. Therefore, cable box arrangement shall be provided on LV side Transformer. The bushing shall be suitable to receive insulated cables from the bottom and connected through cable lugs. Proper clearances shall be maintained for the tank body and side/ cover of the cable box.

i) All porcelain used in bushings shall be homogeneous, non-porous, uniformly glazed to brown colour and free from blisters, burns and other defects.

ii) Stress due to expansion and contraction in any part of the bushing shall not lead to deterioration or loosening of cemented joint.

iii) The creepage distance shall be not less than 25 mm/kV and protected creepage distance shall be less than 50% of total.

iv) Arcing horns are to be provided with adjustable horn gap except the neutral bushing.

v) All applicable routine and type tests certificates of the bushings shall be furnished for approval during detailed engineering.

vi) Bushing shall be supplied with bi-metallic and bi directional/terminal connector for connection to specified ACSR/AAC conductors.

vii) Bushing of identical voltage rating shall be interchangeable.

1.15 PROTECTION & MEASURING DEVICES

i) OIL CONSERVATOR

(a) The conservator shall have adequate capacity between highest and lowest visible levels to meet the requirement of expansion of the total cold oil volume in the transformer and cooling equipment. The conservator shall be bolted into position so that it can be removed for cleaning purposes.

(b) The conservator shall be fitted with magnetic oil level gauge with low level electrically insulated alarm contact. It shall be provided with oil filling hole with cap on top and a drain valve at the bottom.

ii) PRESSURE RELIEF DEVICE

A pressure relief device in form of pressure relief valve with 2 contacts shall be provided of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage of the equipment.

iii) BUCHHOLZ RELAY

A double float type Buchholz relay shall be provided. Any gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. A copper tube shall be connected from the gas collector to a valve at suitable level to facilitate gas sampling with the transformer in service. The device shall be provided with two electrically independent potential free contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

iv) TEMPERATURE INDICATOR

(a) Oil Temperature Indicator (OTI)

The transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication with maximum reading pointer. The thermometer shall have adjustable, electrically independent potential free alarm and trip contacts. Maximum reading pointer and resetting device shall be provided in the marshalling box

(b) Winding Temperature Indicator (WTI)

The transformers shall be provided with a 150 mm dial type thermometer for measuring the hot spot temperature of the winding. **The thermometer** shall have adjustable, electrically independent potential free alarm and trip contacts. Maximum reading pointer and resetting device shall be provided in the marshalling box.

v) **RADIATOR**

Radiator shall be detachable type with lifting lugs, drain plug, air release plug, isolating valves at top and bottom in each radiator. Radiator may be supported from bottom, if required.

Radiator header pipes must not originate from main tank top cover to make top cover removable at site without disturbing radiator.

1.15.1. OIL PRESERVATION EQUIPMENT

The conservator shall be fitted with a dehydrating silica gel filter breather. It shall be so designed that,

i) Passage of air is through a dust filter & Silica gel

ii) Silica gel is isolated from atmosphere by an oil seal.

iii) Moisture absorption indicated by a change in colour of the crystals of the silica gel can be easily observed from a distance.

iv) Breather is mounted not more than 1400 mm above rail top level.

1.15.2. MARSHALLING BOX

i) **Marshalling Box shall be manufactured from CRCA** Steel (not less than 2 mm thick) **which shall be weather**, vermin and dust proof, fitted with required glands, locks, glass door, terminal Board, water-tight hinged and padlocked door of a suitable construction shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. The box shall have sloping roof and the interior and exterior painting shall be in accordance with the specification. Padlock along with duplicate keys shall be supplied for marshalling box. The degree of protection shall be IP-55.

ii) The schematic diagram of the circuitry inside the marshalling box be prepared and fixed inside the door under a prospone sheet.

iii) The marshalling box shall accommodate the following equipment:

a) Temperature indicators
b) Space for accommodating Control & Protection equipment in future for the cooling fan (for ONAF type cooling, may be provided in future))
c) Terminal blocks and gland plates for incoming and outgoing cables.

All the above equipment except (c) shall be mounted on panels and back of panel wiring shall be used for inter-connection. The temperature indicators shall be suitably mounted from the ground level and the door (s) of the compartment(s) shall be provided with glazed window of adequate size.

iv) To prevent internal condensation, a metal clad space heater with thermostat shall be provided. The heater shall be controlled by a MCB of suitable rating mounted in the box. An 11 W CFL shall be provided for illumination with door operated switch.

v) The gland plate and associated compartment shall be sealed in suitable manner to prevent the ingress of moisture.

1.16 FITTINGS & ACCESSORIES

1.16.1. The following major fittings & accessories shall be provided on the transformers:

i) Rating ,Diagram and Terminal marking plate :

(Details on R&D plate shall be finalised during the detailed engineering)

ii) Conservator with oil filling hole and drain arrangement.
iii) Magnetic type oil level gauge (150 mm dia.) with low oil level alarm contacts.
iv) Prismatic/toughened glass oil level gauge.
v) Silica gel breather with oil seal and connecting pipe complete with first fill of activated silica gel.
vi) Double float type Buchholz relay.
vii) Pressure relief valve.
viii) Air release plugs.
ix) Inspection cover.
x) Winding temperature Indicator (150 mm dia)
xi) Oil temperature indicator.(150mmdia)
xii) Lifting lugs / Pulling lugs.
xiii) filter valves – 2 Nos.
xiv) Sampling valves.
xv) Drain valve.
xvi) Two earthing terminals
xvii) Bidirectional flanged rollers.
xviii) Radiators (one set).
xix) A set of HV and LV Bushings along with terminal connectors and arcing horn **(as applicable)**.
xx) LV Neutral Bushing for ground connection.

Note: (i) The fittings listed above are indicative and any other fittings which are generally required for satisfactory operation of the transformer are deemed to be included in the quoted price of the transformer.

1.17 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 shall be as per NEMA stipulations.

1.18 INSPECTION AND TESTING

(i) The Contractor shall draw up and carry out a comprehensive inspection and testing programme during manufacture of the transformer duly approved by the purchaser.

(ii) The contractor shall carry out type tests, acceptance test and routine tests on the transformers.
(iii) The pre-shipment checks shall also be carried out by the contractor.

1.19 ROUTINE TESTS

All routine tests in accordance IS: 2026 as per latest amendments shall be carried out.

1.20 TYPE TEST

The following type tests shall be conducted on the first transformer manufactured under the contract. Further manufacturing of transformers shall proceed only after successful completion of these tests and approval of test reports by the Owner:

i) Temperature Rise Test

ii) Tank Vacuum test

iii) Tank Pressure Test

iv) Lightning impulse withstand test

v) Short Circuit Test

1.21 ACCEPTANCE TESTS

The following acceptance tests are carried out in presence of purchaser representative

(i) Visual examination and checking the dimension
(ii) Measurement of winding DC resistance at **all** taps.
(iii) Voltage ratio on each tapping and check of voltage vector relationship.
(iv) Impedance voltage at all tappings.
(v) Load losses.
(vi) No load losses and no load current.
(vii) Induced over voltage withstand test.
(viii) Phase relation, polarity, angular displacement and phase sequence test
(ix) Separate source voltage withstand test .
(x) Measurement of Zero sequence impedance.

(xi) Dielectric tests
(xii) Measurement of Insulation resistance test
(xiii) Oil sample test for BDV and moisture content.

1.22 CAPITALISATION OF LOSSES AND LIQUIDATED DAMAGES

The capitalization of guaranteed losses of the transformer shall be calculated and considered while evaluating the bids. Liquidated damages will be applied to successful bidder for not achieving the quoted guaranteed figures. The manner of bid evaluation and levy of liquidated damages shall be in accordance with Special Conditions of Contract.

The guaranteed values of no load losses and load losses shall be stated in the bid. Transformers with lower losses shall be preferred.

The rate of capitalisation of losses shall be as below:

i) Iron Loss – Rs.2,61,713/- per kW.
ii) Copper Loss – Rs.1,18,643 per kW.

1.23 SPARE PARTS

In case the manufacturer goes out of production of spare parts, then he shall make available the drawings of spare parts and specification of materials at no extra cost to the Purchaser to fabricate or procure spare parts from other sources.

1.23.1. INSTRUCTIONS MANUAL

Eight sets of the instruction manuals shall be supplied at least four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection, operation and maintenance of the transformer.

1.23.2. The manuals shall include amongst others, the following particulars:
(i) Marked erection prints identifying the components, parts of the transformer as dispatched with assembly drawings.
(ii) Detailed dimensions, assembly and description of all auxiliaries.

(iii) Salient technical particulars of the transformer.
(iv) Copies of all final approved drawings.
(v) Detailed O&M instructions with periodical check lists etc.

1.23.3. COMPLETENESS OF EQUIPMENT

1.23.4. All fittings and accessories, which may not be specifically mentioned in the specification but which are necessary for the satisfactory operation of the plant, shall be deemed to be included in the specification and shall be furnished by the contractor without extra charges. The equipment shall be complete in all details, whether such details are mentioned in the specification or not, without any financial liability to the Purchaser under any circumstances.

1.24 COMMISSIONING

The equipment shall be commissioned as per CBIP manual, IS 10028 and manufacturer's recommendations.

2.0 STATION TRANSFORMER

2.1 INTRODUCTION

This chapter covers specification of **33/0.433kV and 11/0.433kV** oil immersed, naturally cooled, three-phase, 50 Hz, double-wound, copper winding, outdoor type Station Transformer complete with all accessories and fittings as specified herein.

Unless otherwise modified in this specification, the **Station** Transformers shall comply with the latest versions of Indian Standard Specifications IS: 2026. The losses will not be more than those prescribed for as per guidelines issued by Govt. of India/CEA.

2.2 STANDARDS

The transformer shall conform in all respect to the relevant Indian/International Standard Specification, with latest amendments thereof, some of which are listed below:

Indian Standard	Title	International standards
IS-2026: (Part I to IV) 1977-81	Specification for Power Transformer	IEC- 76
IS- 335/1983	Insulating Oil for transformer & Switchgear	BS –148
IS-3639: 1968	Fittings & Accessories for Power transformer	ASTM D-1275
IS-2099: 1986	High Voltage Porcelain Bushings	IEC 296-1969
IS- 7421-1988	Low Voltage Porcelain Bushings	
IS-3347	Dimensions for Outdoor Bushings	DIN 42531 to 33
IS-12444	Specification for Copper wire rods	ASTM B-49
IS-5/1961	Specification for colours for ready mixed paints	
IS-6600/1972	Guide for loading of oil immersed Transformers	

Indian Standard	Title	International standards
CBIP Publication, No.275	Manual on transformer	

2.3 PRINCIPAL PARAMETERS

The transformer shall be suitable for outdoor service. The electrical parameters of the transformer shall be as follows:

1.	Rated HV voltage	33 kV or 11 kV
2.	Rated LV voltage	433V
3.	Connection (HV)	Delta
4.	Connection(LV)	Star
5.	Vector Group	Dy n 11
6.	Material of winding	Copper, double wound type
7.	Type of cooling	ONAN
8.	Maximum current density in HV & LV windings	2.6 A/mm2
9.	Maximum flux density at normal voltage and frequency	1.6 Tesla
10.	Method of system earthing	Neutral Solidly earthed.
11.	Range of tap changer	+5% to -10% in equal steps of 2.5% each on HV winding.
12.	Type of tap Changer	Off -circuit tap changer
13.	No load voltage ratio	33000/433V or 11000/433 V

2.4 TEMPERATURE RISE

The transformer shall be capable of operating continuously at its normal rating without exceeding the temperature rise limits of 45 deg C (measured by resistance) for transformer windings and 40 deg C (measured by thermometer) in top oil above the ambient temperature of 50 deg C when tested in accordance with IS: 2026. Transformer with higher temp rise will not be accepted.

The limit of temperature rise mentioned above will have to be demonstrated by the successful bidder by carrying the Heat run test as per IS: 2026.

2.5 CAPITALIZATION OF LOSSES & LIQUIDATED DAMAGES

The capitalization of losses of the transformer and Liquidated Damages will not be applicable. However, the losses will not be more than those prescribed for Level-3 Transformer of relevant rating in Table-3 & clause 6.8.1.3 of IS1180 (Part-I).

As already mentioned, the losses will not be more than those prescribed as per guidelines issued by Govt. of India/CEA (560 watts max. losses at 50% loading and 1820 watts max. losses at 100% loading for 33/0.433 kV , 100 kVA station Transformer) while the capitalisation of losses will be as above. Therefore, the bidder will quote the following loss figures for station transformer-

1. Max. losses at 50% loading (Watts)
2. Max. losses at 100% loading (Watts)
3. Iron Loss
4. Copper Loss

2.6 IMPEDANCE

The percentage impedance at 75 deg.C shall be 4.5% subject to a tolerance as per IS: 2026.

2.7 WINDING

2.7.1. The primary (HV) windings shall be connected in Delta and the secondary (LV) winding in Star (Vector group Dyn11). The neutral of secondary windings shall be brought out to a separate insulated neutral terminal for earthing.

2.7.2. The winding shall be so designed as to produce minimum out of balance forces in the transformers at all tap positions.

2.7.3. The winding design shall ensure that all the coil assemblies are of identical design and shall be interchangeable and repairing of the winding could be made easily without special equipment. It should ensure free circulation of oil and avoid any hot spot.

2.7.4. The conductor used in the winding shall be electrolytic copper of 99.99 percent purity, best suitable to the equipment and all the permanent current carrying joints in the winding and leads shall be properly sleeved and crimped instead of jointing with solder or welding. All HV & LV coil ends shall be provided with crimped lugs.

2.7.5. Electrical Grade Plain Insulation Kraft paper in layer(s) to be used for interlayer insulation shall be of uniform density and free from any foreign particles and shall conform to IS: 698/56 with latest amendments thereof. The end turn of each layer shall be properly and fully covered with insulation and rigidly supported to avoid interlayer flashover or injury from vibration. Dovetailed spacers shall be used between the sections of HV windings. All material used in the insulation and assembly of the winding shall be insoluble, non catalytic and chemically inactive and shall not soften, ooze out, shrink or collapse in hot transformer oil during service or otherwise be adversely effected under operating conditions.

The core and coil assembly shall be completely dried before placing in the tank and in fully dried out in 'Air Drying oven' till the coils are shrunk to the designed level and are in contact with the transformer oil.

2.8 CORE CONSTRUCTION

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

Stage level inspection for core construction may be carried out by the Purchaser.

Each lamination shall be insulated such that it will not deteriorate due to mechanical pressure and the action of hot transformer oil. The core insulation should withstand power frequency voltage of 2 kV for one minute.

The core shall be constructed from high grade, non-aging Cold Rolled Grain Oriented (CRGO) silicon steel laminations conforming to grade M4 or better. The Contractor should offer the core for inspection and approval by the Employer during the manufacturing stage. The call notice for the purpose should be accompanied with the following documents as, applicable, as a proof towards use of prime core material:

Invoice of the Supplier
Mills test certificate
Packing list
Bill of lading
Bill of entry certificate to customs

Core material shall be directly procured either from the manufacturer or through their accredited marketing organization of repute.
The value of the flux density allowed in the design and grade of lamination used shall be clearly stated in the offer. The maximum continuous flux density shall be1.6 Tesla at normal voltage and frequency on any tap position. With plus 10 percent voltage variation corresponding to the tap the flux density shall not exceed 1.9 Tesla. The bidder shall provide saturation curve of the core material proposed to be used.

All parts of the core shall be of robust design, capable of withstanding any shocks to which they may be subjected during handling, lifting, transportation, installation and service. Clamping of core and winding assembly with tank should be done by angle iron pieces, welded to tank walls. Adequate arrangement like Lifting lugs shall be provided to enable the core and winding assembly to be lifted from the tank.
Oil ducts to be provided where necessary to ensure adequate cooling. There should be no obstruction to free flow of oil.
Presence of pockets, which would prevent complete emptying of the tank through the drain valve to be avoided.

Use of seconds CRGO steel for core construction is strictly prohibited.

2.9 TANK CONSTRUCTION

The tank shall be of rectangular shape with round edges or round shape and be fabricated from **high grade low carbon steel of** tested quality of adequate thickness .e. minimum 3.15 mm. (for side walls) and 5.00 mm. (for top & bottom plates).
The tank shall be suitably stiffened to provide rigidity and to withstand the short circuit current. The stiffeners wherever applicable are to be provided on all the four sidewalls of the tank and suitably designed to prevent retention of water.

The tank cover shall be slightly sloping towards HV bushing and designed for easy drainage of water.

The transformer tank shall be complete with all accessories, lifting lugs and shall be designed to allow the complete transformer tank, filled with oil to be skidded and lifted by crane or jacks etc. without risk of any damage and transported by Rail/Road without straining any joint and without causing leakage of oil.

The tank should withstand the vacuum and continuous internal pressure over normal hydrostatic pressure of oil as well as pressure developed due to abnormal condition, which may arise during service. It should be designed to avoid collection of gas or air.
Bolted inspection openings to be provided on the sides of the tank to observe the position of the core, coil assembly, fittings and fixtures and other internal components.

Radiators shall be provided for adequate cooling.

2.10 CLEARANCES

2.10.1. EXTERNAL

The external electrical clearance between phase to phase and phase to earth in accordance with Clause 7.1 of IS: 2099 shall not be less than the values given below:-

Voltage	Medium	Clearance Phase to Phase (mm)	Clearance Phase to earth (mm)
33 kV	**Air**	**360**	**210**
11 kV	Air	280	140
433 V	Air	75	40

2.11 BUSHINGS

Bushings arrangement: The transformer shall be fitted with three high voltage outdoor type easily replaceable porcelain bushings The bushing rod shall be of brass. Each terminal including the neutral shall be distinctly marked and coloured for phase voltage on both HV and LV sides. The system of marking shall be in accordance with the latest amendment of IS: 2026.

LV side bushings shall be inside a cable box fitted on the side of the tank, which shall be suitable to receive insulated cables from the bottom and connected through cable lugs. Proper clearances shall be maintained for the tank body and side/ cover of the cable box.

The electrical characteristics of high voltage bushing shall conform to latest version of IS: 2099, IS 3347 and **IS 8603.** The low voltage bushing shall conform to latest version of IS: 7421. All porcelain bushing shall be homogeneous, free from other flaws effecting its mechanical strength or dielectric quality. They should be well vitrified, smoothly glazed, tough and impervious to moisture.

Bushing terminals: To avoid bimetallic action at the point of connection to the copper windings and to the external aluminium cables/conductors, both HV & LV bushing stems shall be made of aluminium alloy/copper conforming to the requirements of IS:3347

The HT bushing terminals shall be screwed type fitted with terminal connectors to receive **AAAC/ ACSR conductor**. **For LT side**, the cable lugs are to be connected directly to the bushing.

Arcing horns to be provided with adjustable type rod gap with the HT bushings. The terminal connectors shall receive bare overhead AAAC/ ACSR conductor on HT side & cable on LT side of adequate size & ratings.

2.11.1. All screws, nuts and fasteners and Clamps and fittings exposed to atmosphere of iron and steel to be hot dip galvanized as per IS:2633 and as detailed in General Technical Specification.

2.11.2. The minimum creepage distance of the bushings shall be 25 mm per kV.

2.12 FITTINGS AND ACCESSORIES

2.12.1. All transformers shall be fitted with the following major fittings & accessories :

i. Conservator with drain plug and filling hole etc.
ii. Two earthing terminals
iii. Oil level Indicator
iv. Lifting / Pulling lugs
v. Rating, diagram and terminal marking plate(s)

vi. Silica gel breather of approved design which should contain new dehydrated silica gel.
vii. Drain-cum-sampling valve
viii. Filter valves - 2 Nos.
ix. Thermometer pocket
x. Oil temperature indicator (150mm dia)
xi. Air Release Plug
xii. Pressure relief valve.
xiii. Radiators .
xiv. Bi –metallic terminal connectors for HV bushings.
xv. A set of HV and LV bushings.
xvi. Off-load Tap changer with operating switch.
xvii. arcing horns
xviii. A set of Gaskets
xix. Inspection Cover

2.13 CONSERVATORS

2.13.1. Conservator shall be provided with each transformer bolted into position. It should be of adequate capacity between highest and lowest visible levels to meet the requirement of expansion of oil from minimum ambient temperature up to 100 Degree Celsius.
The oil level gauge and the silica gel breathing device shall be fixed to the conservator, which shall also be provided with a drain plug and a filling hole with a cover. In addition, the cover of the main tank shall be provided with an air release plug to enable trapped air to be released.

2.14 SEALING GASKETS

2.14.1. All sealing washers/gaskets shall be made of 'oil and heat resistant Nitrile/Neoprene rubber/synthetic rubber bonded cork type RC-70C gaskets. Gaskets made of natural rubber or cork sheet are not permissible.

2.15 TRANSFORMER OIL

The transformer shall be supplied complete with first filling of oil The insulating oil shall be new and of reputed make complying with the requirements of IS: 335/1983 with latest version thereof or BS: 148. No inhibitors shall be provided.

2.16 BASE MOUNTING ARRANGEMENT

The under base of all transformers shall be provided with two 75x40x6mm channels.

2.17 RATING AND TERMINAL MARKING PLATE (S)

Each transformer shall be provided with non-detachable rating, diagram and terminal marking plate(s) of weather proof material, fitted in a visible position and showing the complete information as given under IS: 2026 (Part-I) - 1981. Further, each transformer shall have inscription of Owner name-and Purchase order and date.

2.18 OFF CKT TAP CHANGER

An off load tap changer device with switch at side shall be provided. The taps shall be in steps in the HV winding for HV variation of +5% to –10% in steps of 2.5%.

2.19 TESTS

2.20 ROUTINE TESTS

All transformers shall be subjected to routine tests at the manufacturer's works in accordance with IS: 2026 & IS: 1180 as per latest amendments.

2.21 ACCEPTANCE TESTS

The following acceptance tests are to be carried out in presence of Purchaser representative

i. Visual examination and measurement of dimensions.

ii. Measurement of winding **DC** resistance at **all** taps.

iii. Measurement of voltage ratio and check of voltage vector relationship.

iv. Measurement of impedance voltage/short circuit impedance and load-loss.

v. Measurement of no-load loss and current at full voltage.

vi. Measurement of insulation resistance.

vii. Induced over-voltage withstand test

viii. Separate-source voltage withstand test

ix. Dielectric Tests

x. Oil sample test for BDV and moisture content.

xi. Measurement of zero sequence impedance.

2.22 TYPE TESTS

The following type tests **shall be conducted on the first transformer manufactured under the contract. Further manufacturing of transformers shall proceed only after successful completion of these tests and approval of test reports by the Owner:**

i. Impulse-test

ii. Temperature rise test

iii. Air pressure test

iv. Vacuum test

v. Short Circuit test

2.22.1. TEST VOLTAGES

Transformers shall be capable of withstanding the power frequency and impulse test voltage prescribed below:

Nominal system voltage	Highest voltage	Impulse test voltage	1 minute Power frequency voltage

433 V rms			3 kV (rms)
11 kV rms	12 kV (rms)	75 kV (Peak)	28 kV (rms)
33 kV rms	36 kV (rms)	170 kV (Peak)	70 kV (rms)

Annexure-II

On load tap changer for 33/11KV Power Transformer:

The tapping range of On Load Tap Changer shall be +5% to -15% in steps of 1.25% each. The no of taps shall be 17.The On Load Tap Changer shall be supplied with RTCC panel and AVR (Automatic Voltage Regulating Relay)

The Continuous current rating of the tap changer shall be based on connected winding rating and shall have liberal and ample margin. Lower rated tap changers connected in parallel are not acceptable.

The on-load tap changing equipment shall have the provision for mechanical and electrical control from a local position and electrical control from a remote position. For local mechanical operation, the operating handle shall be brought outside the tank for operation from floor level with provision to lock the handle in each tap position. Remote electrical operation shall have an AUTO-MANUAL selection at the remote location. When selected AUTO, the tap changing gear shall maintain steady voltage within practical limit on the transformers secondary bus from which the reference shall not respond to transient variation of voltage due to grid disturbance and system fault.

The required voltage relay shall not be sensitive to frequency variation and shall be suitable for sensing voltage from the secondary of potential transformers mounted on the 66KV, 33KV, or 11KV bus.

The tap changer shall be provided with over-current protection in order to prevent the tap-change operation during a short circuit, which would to greatly stress the contacts of the diverter switch. The function of protection shall be arranged as follows;

(i) Whenever over current occurs, the control circuit for commanding OLTC motor operation shall be blocked by the normally close contracts of the over current relays.

(ii) If during tap change over current occurs, the OLTC motor circuit shall be blocked through the mechanical cam switch, which is close from the very beginning to the very end of every tap change operation and to the normally open contacts of the over current relays. The stop action of the motor shall be made through the motor brake contactor.

The design of the tap changing equipment shall be such that the mechanism will not stop in any intermediate position; however, if the mechanism through faulty operation does stop in an intermediate position, the full load must be carried by the transformer without injury to the equipment. The mechanical position indicator shall be equipped in the motor drive cubicle. The motor shall be designed to be of step control. In any case the operation shall be of step by step.

The **voltage regulating relay** shall be supplied together with the timer and under voltage relay. The signal order from the voltage regulating relay to execute the tap changer operation, when the regulating voltage is out of the voltage regulating level shall be designed to be delayed by the adjustable timer. If the control voltage abnormally falls, the movement of the tap changer shall be locked by the contact of the under voltage relay, even if the contacts of the voltage regulating relay are working.

The control circuit of the transformer shall be completely designed and provisions shall be made for parallel operation with another transformer.

The following accessories, control and selector switches and other necessary accessories shall be furnished.

Remote tap changer control board

(Placed in the control room)

- Voltmeter
- "AUTO-MANUAL" control switch
- "RAISE-LOWER" control switch
- Tap position indicator
- Tap changer operation program indicator.

Transformer Tap Changer driving mechanism control cubicle

- "REMOTE-LOCAL-TEST" selector switch
- "AUTOMATIC-MANUAL" control switch
- "RAISE-LOWER" control switch
- Tap position indicator
- Tap changer operation program indicator
- Voltmeter
- Tap change operation counter
- Means for manual operation when power supply is lost

Annexure-III

Tank Test Procedures

Vacuum Test

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

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

Pressure Test

All transformer tanks, its radiator, conservator vessel and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/m2 whichever is lower measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

Annexure-IV (Painting)

1. PAINTING (Power Transformer & Station Transformer)

This section describes the painting procedure, technical requirements, constructional features and testing requirement for various type of transformers.

1.1. PAINTING PROCEDURE

Surface Preparation for Main tank, Pipes, Conservator tank etc. -All surfaces of transformer main tank, pipes, turrets, conservator tank etc. shall be thoroughly blast cleaned with sand, shot or grit in accordance with ISO:8501 Part 1 or Swedish standard SIS: 055900 to a minimum standard of Sa2½ to make the surface free from visible oil, grease & dirt, mill scale, rust, paint coatings and foreign matter. Machined areas and threaded components etc are to be covered during blasting to prevent damage.

The compressed air that is used for blasting should be dry and free from oil. The flanges, angles, tank curbs and other such areas shall be preferably blast cleaned prior to fabrication and paint these with one coat of pre-fabrication primer prior to fabrication. After adequate blast cleaning of each large surface where blasting time is more than three hours, an overall blast cleaning is to be done on the entire surface once more so that entire surface areas is exposed as fresh for first coat of primer paint. The first coat of primer paint should be applied not later than 3-4 hours after preparation of surface to avoid oxidation.

Surface Preparation for radiator-All internal and external surfaces of radiator shall be thoroughly cleaned either by chemical cleaning or by blast with sand, shot or grit in accordance with ISO 8501 Part 1 or Swedish standard SIS 055900 to make the surface free from visible oil, grease & dirt, mill scale, rust, paint coatings and foreign matter. Suitable chemical should be used for chemical cleaning, if required. The compressed air that is used for blasting should be dry and free from oil. After adequate surface cleaning, the first coat of primer paint/varnish should be applied not later than 3-4 hours after preparation of surface to avoid oxidation.

2.22.2. PAINTING- EXTERNAL & INTERNAL SURFACES

Painting shall be carried out in closed and dust free area. The external surface shall be coated with suitable layers of paint and to form an impermeable layer so that air and water cannot reach the substrate. The paint selected shall be stable in outdoor condition such as rain, sunlight, pollution etc. Paint used for primer, under coat and top or finish coat should be from the same manufacturer and compatible to each other. In case in the rare event, paint used for primer, under coat and finish coat are not from the same manufacturer the compatibility test of the paint from different source shall be carried out. Painting shall be applied as per the recommendation of the paint manufacturer. The number of coats shall be such that the minimum dry film thickness (DFT) specified is achieved. The DFT of painted surface shall be checked with a measuring gauge to ensure specified DFT. Complete painting scheme for the transformer is tabulated below:

Painting-Transformer Main tank, pipes, conservator tank, radiator etc.-

	Surface Preparation	primer coat	intermediate under coat	finish coat	total DFT	Colour shade
Main tank, pipes, conservator tank, etc. (External surfaces)	Blast cleaning Sa2½	Epoxy base Zinc primer 30-40 micron	Epoxy base Zinc primer 30-40 micron	Aliphatic Polyuret hane (PU Paint) (min 50 micron	Min 110 micron	697 shade as per IS:5/ POWER GRID approved drg.
Main tank, pipes (above 80 NB), conservator tank, etc (Internal surfaces)	Blast cleaning Sa2½	Hot oil resistant, non-corrosive varnish or paint or epoxy	--	--	Min 30 micron	Glossy white for paint POWER GRID appd. Drg.
Radiator (External surfaces)	Chemical / blast cleaning (Sa2½)	Epoxy base zinc primer 30-40 micron	Epoxy base Zinc primer Min 30-40 micron	Aliphatic Polyureth ane(PU Paint) (min)50 micron	Min 110 micron	Matching shade of tank/ different shade aesthetically matching to tank/ POWERGRID approved Drg.

Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning if required	Hot oil proof low viscosity varnish, Flushing With Trfr. Oil	--	--	--	POWERGRID approved Drg.

Surface Preparation for Control cabinets/Marshalling Boxes-Surface Preparation for all Transformer Control cabinets/Marshalling Boxes shall be carried out by Seven-Tank process/ shot blasting procedure confirming to following Indian standard in dust free area:

(i) IS: 3618-1966: Degreasing by solvent wiping: Phosphate Treatment of Iron &Steel for Protection against corrosion.

(ii) IS: 6005-1970: Code of Practice for phosphating of Iron & Steel.

2.22.3. Sequence of tanks with required size suitable to handle all Transformer Control cabinets/Marshalling Boxes/ shall be as per following:

(i) Degreasing tank: Plain welded M.S. tank with suitable supports for suspending the jobs with overflow arrangement/scoop trough to collect floating oils.

(ii) Derusting tank: PVC/FRP lined mild steel tank.

(iii) Phosphating tank: FRP lined mild steel tank.

(iv) Passivating tank: Mild steel tank.

(v) Rinse Tanks :(3 Nos.-1No. Each after Degreasing, Derusting and Phosphating) Mild steel tanks with overflow arrangement.

(vi) Driers: Suitable air blowers.

2.22.4. **CHEMICALS**

Suitable chemicals should be used and concentration of chemicals /weight of Phosphate coating should be checked regularly as per recommendation of the chemical manufacturer and applicable IS.

2.23 INSPECTION

The surface for application of paint should be dry, free from oil, dirt, acid & loose adhering powder and reasonably smooth in finish without uncovered areas, rusty surfaces and roughness.

Painting- Control cabinets/Marshalling Boxes - Outdoor Painting scheme is tabulated below:

PRIMER COAT	INTERMEDIATE UNDERCOAT	FINISH COAT	TOTAL DFT	COLOUR SHADE
Epoxy base Zinc primer (30-40 □m)	Epoxy base Zinc Primer (30-40 □m)	Aliphatic Polyurethane (PU Paint) (min 50 □m)	Min 110 □m	697 shade as per IS:5/POWERGRID approved Drg

2.

33/11kV Power Transformers shall be of “Off Load Tap Changer” type. On LV side, the connections will be done with armoured XLPE cable. Therefore, cable box arrangement shall be provided on LV side Transformer.