Technical Specification for 33/11kV Power Transformers
PART 1: GENERAL

1. SCOPE

This specification covers the design, engineering, manufacture, testing, supply, delivery, offloading and performance requirements of 33/11kV power transformers for use in the primary substations of the Discom’s namely NESCO, WESCO & SOUTHCO of Orissa. The transformers shall be double copper wound, three phase, oil immersed with ONAN cooling and fitted with on load tap changers for 8.00 MVA Transformer only. The ratings required are 3.15 MVA, 5.0 MVA and 8.0 MVA.

The transformer shall conform in all respects to highest standards of engineering, design, workmanship, this specification and the latest revisions of relevant standards at the time of offer and the Purchaser shall have the power to reject any work or material, which, in his judgement, is not in full accordance therewith.

2. STANDARDS

Except where modified by this specification, the transformers shall be designed, manufactured and tested in accordance with the latest editions of the following standards. The Bidder may propose alternative standards, provided it is demonstrated that they give a degree of quality and performance equivalent to or better than the referenced standards. Acceptability of any alternative standard is at the discretion of the Purchaser. The Bidder shall furnish a copy of the alternative standard proposed along with the bid. If the alternative standard is in a language other than English, an English translation shall be submitted with the standard. In the case of conflict the order of precedence shall be
1) IEC or ISO Standards, 2) Indian Standards, 3) other alternative standards.

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IEC 606  Application guide for power transformers.
IEC 616  557  Terminal and Tapping markings for power transformers.
ISO 1460  2629  Galvanising.

This list is not to be considered exhaustive and reference to a particular standard or recommendation in this specification does not relieve the Supplier of the necessity of providing the goods complying with other relevant standards or recommendations.

3. **SERVICE CONDITIONS**

The service conditions shall be as follows:

- maximum altitude above sea level 1,000m
- maximum ambient air temperature 50°C
- maximum daily average ambient air temperature 35°C
- minimum ambient air temperature 0°C
- maximum temperature attainable by an object exposed to the sun 60°C
- maximum yearly weighted average ambient temperature 32°C
- maximum relative humidity 100%
- average number of thunderstorm days per annum (isokeraunic level) 70
- average number of rainy days per annum 120
- average annual rainfall 150 cm
- maximum wind pressure 94.3 kg/m²

Environmentally, the region where the work will take place includes coastal areas, subject to high relative humidity, which can give rise to condensation. Onshore winds will frequently be salt laden. On occasions, the combination of salt and condensation may create pollution conditions for outdoor insulators.

Therefore, outdoor material and equipment shall be designed and protected for use in exposed, heavily polluted, salty, corrosive and humid coastal atmosphere.

Indoor material and equipment shall be designed and protected for use in buildings, which occasionally may be wet and damp.
4. SYSTEM CONDITIONS

The equipment shall be suitable for installation in supply systems of the following characteristics:

- Frequency 50Hz

- Nominal system voltages
  - 33kV
  - 11kV
  - 400/230V

- Maximum system voltages:
  - 33kV System 36.3kV
  - 11kV System 12.1kV
  - LV System 476V

- Minimum LV voltage 340V

- Nominal short circuit levels:
  - 33kV System 25kA
  - 11kV System 12.5kA

- Insulation levels:
  - 1.2/50 ms impulse withstand (positive and negative polarity):
    - 33kV System 170kV
    - 11kV System 75kV

- Power frequency one minute withstand (wet and dry)
  - 33kV System 70kV
  - 11kV System 28kV
  - LV System 3kV

- Neutral earthing arrangements:
  - 33kV System solidly earthed
  - 11kV System solidly earthed
  - LV System solidly earthed

5. COMPLIANCE WITH SPECIFICATION

The transformers shall comply in all respects with the requirements of this specification. However, any minor departure from the provisions of the specification shall be disclosed at the time of tendering in the Non Compliance Schedule in Part 3 of this document.

The mass and dimensions of any item of equipment shall not exceed the figures stated in the Schedules.
6. **COMPLIANCE WITH REGULATIONS**

All the equipment shall comply in all respects with the Indian Regulations and acts in force. The equipment and connections shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire.

7. **QUALITY ASSURANCE, INSPECTION AND TESTING**

7.1. **General**

To ensure that the supply and services under the scope of this contract, whether manufactured or performed within the Supplier’s works or at his sub-supplier’s premises or at any other place of work are in accordance with this specification, with the regulations and with relevant authorised International or Indian Standards, the Supplier shall adopt suitable quality assurance programmes and procedures to ensure that all activities are being controlled as necessary.

The quality assurance arrangements shall conform to the relevant requirements of ISO 9001 or ISO 9002 as appropriate.

The systems and procedures which the Supplier will use to ensure that the plant complies with the contract requirements shall be defined in the Supplier’s quality plan for the works.

The Supplier shall operate systems which implement the following:

- **Hold Point** “A stage in the material procurement or workmanship process beyond which work shall not proceed without the documented approval of designated individuals or organisations.”

The Purchaser’s written approval is required to authorise work to progress beyond the Hold Points indicated in approved quality plans.

- **Notification Point** “A stage in material procurement or workmanship process for which advance notice of the activity is required to facilitate witness.”

If the Purchaser does not attend after receiving documented notification in accordance with the agreed procedures and with the correct period of notice then work may proceed.

7.2. **Quality Assurance Programme**

Unless the Supplier’s quality assurance system has been audited and approved by the Purchaser, a Quality Assurance Programme for the Works shall be submitted to the Purchaser for approval a minimum of one month from contract award, or such other period as shall be agreed with the Purchaser. The Quality Assurance Programme shall give a description of the quality system for the works and shall, unless advised otherwise, include details of the following:

- The structure of the organisation
- The duties and responsibilities assigned to staff ensuring quality of work
- The system for purchasing, taking delivery and verification of materials
- The system for ensuring quality of workmanship
- The system for control of documentation
- The system for the retention of records
- The arrangements for the Supplier’s internal auditing
7.3. Quality Plans

The Supplier shall draw up for each section of the work quality plans which shall be submitted to the Purchaser for approval at least two weeks prior to the commencement of work on the particular section. Each quality plan shall set out the activities in a logical sequence and, unless advised otherwise, shall include the following:

- An outline of the proposed work and programme sequence
- The structure of the Supplier’s organisation for the contract
- The duties and responsibilities assigned to staff ensuring quality of work for the contract
- Hold and notification points
- Submission of engineering documents required by the specification
- The inspection of materials and components on receipt
- Reference to the Supplier’s work procedures appropriate to each activity
- Inspection during fabrication/construction
- Final inspection and test

7.4. Non-conforming Product

The Purchaser shall retain responsibility for decisions regarding acceptance, modification or rejection of non-conforming items.

7.5. Sub-suppliers

The Supplier shall ensure that the quality assurance requirements of this specification are followed by any sub-suppliers appointed by him under the Contract.

The Supplier shall assess the sub-supplier’s quality assurance arrangements prior to his appointment to ensure compliance with the appropriate ISO 9000 standard and the specification. Auditing of the sub-supplier’s quality assurance arrangements shall be carried out by the Supplier and recorded in such a manner that demonstrates to the Purchaser the extent of the audits and their effectiveness.

7.6. Inspection and Testing

The Purchaser shall have free entry at all times, while work on the contract is being performed, to all parts of the manufacturer's works which concern the processing of the equipment ordered. The manufacturer shall afford the Purchaser without charge, all reasonable facilities to assure that the equipment being furnished is in accordance with this specification.

The equipment shall successfully pass all the type tests and routine tests referred to in Clause 41, Part 2 and those listed in the most recent edition of the standards given in Clause 2, Part 1 of this specification.
The Purchaser reserves the right to reject an item of equipment if the test results do not comply with the values specified or with the data given in the technical data schedule.

Type tests shall be carried out at an independent testing laboratory or be witnessed by a representative of such laboratory or some other representative acceptable to the Purchaser. Routine tests shall be carried out by the Supplier at no extra charge at the manufacturer's works.

Type tests may be dispensed with at the Purchaser's discretion if the Supplier furnishes evidence to the Purchaser's satisfaction that the relevant tests have already been performed on identical equipment. In this case test certificates shall be submitted with the bid for evaluation.

The Purchaser may witness routine and type tests. In order to facilitate this, the Supplier shall give the Purchaser a minimum of four weeks notice that the material is ready for testing. If the Purchaser does not indicate his intention to participate in the testing, the manufacturer may proceed with the tests and shall furnish the results thereof to the Purchaser.

Full details of the proposed methods of testing, including connection diagrams, shall be submitted to the Purchaser by the Supplier for approval, at least one month before testing.

All costs in connection with the testing, including any necessary re-testing, shall be borne by the Supplier who shall provide the Purchaser with all the test facilities which the latter may require, free of charge. The Purchaser shall have the right to select the samples for test and shall also have the right to assure that the testing apparatus is correct. Measuring apparatus for routine tests shall be calibrated at the expense of the Supplier at an approved laboratory and shall be approved by the Purchaser.

The Supplier shall be responsible for the proper testing of the plant or materials supplied by sub-suppliers to the same extent as if the work, plant or materials were completed or supplied by the Supplier.

Any cost incurred by the Purchaser in connection with inspection and re-testing as a result of failure of the equipment under test or damage during transport or offloading shall be to the account of the Supplier.

The Supplier shall submit to the Purchaser five signed copies of the test certificates, giving the results of the tests as required. No materials shall be dispatched until the test certificates have been received by the Purchaser and the Supplier has been informed that they are acceptable.

The test certificates must show the actual values obtained from the tests, in the units used in this specification, and not merely confirm that the requirements have been met.

In the case of components for which specific type tests or routine tests are not given in Part 2, or in the quoted standards in Clause 2, of this specification, the Supplier shall include a list of the tests normally required for these components. All materials used in the Contract shall withstand and shall be certified to have satisfactorily passed such tests.

No inspection or lack of inspection or passing by the Purchaser’s Representative of equipment or materials whether supplied by the Supplier or sub-supplier, shall relieve the Supplier from his liability to complete the contract works in accordance with the contract or exonerate him from any of his guarantees.

7.7. Guarantee

The Supplier shall guarantee the following:

- Quality and strength of materials used.
• Satisfactory operation during the guarantee period of FIVE years from the date of commissioning, or 72 months from the date of acceptance of the equipment by the Purchaser following delivery, whichever is the earlier.

• Performance figures as supplied by the tenderer in the schedule of guaranteed particulars.

8. PROGRESS REPORTING

The Supplier shall submit for approval within 4 weeks of the starting date of the contract, an outline of production, inspection, delivery and erection chart. Within a further period of 4 weeks, the Supplier shall provide a detailed programme of the same information in the form to be agreed by the Purchaser. The Supplier shall submit two copies of monthly progress reports not later than the 7th day of the following month. The reports shall show clearly and accurately the position of all activities associated with the material procurement, manufacture, works tests and transport with regard to the agreed contract programme.

The preferred format for presentation of programmes is MS Project Version 4.0. Programmes and monthly updates should be submitted on 3.5” diskettes.

The design aspect of the progress report shall include a comprehensive statement on drawings, calculations and type test reports submitted for approval.

The position on material procurement shall give the dates and details of orders placed and indicate the delivery dates quoted by the manufacturer. If any delivery date has an adverse effect on the contract programme, the Supplier shall state the remedial action taken to ensure that delays do not occur.

The position on manufacture shall indicate the arrival of raw material and the progress of manufacture. Any events that may adversely affect completion in the manufacturer’s works shall also be reported.

All works tests executed shall be listed and test results shall be remarked upon. Any test failure shall be highlighted.

The dispatch of each order shall be monitored on the progress report giving the date by which the equipment will be available for transport, the estimated time of arrival on site and the dates actually achieved.

Delays or test failures in any part of the programme which may affect any milestone or final completion dates shall be detailed by the Supplier who shall state the action taken to effect contract completion in accordance with the contract programme.

9. SPARE PARTS AND SPECIAL TOOLS

The Supplier shall provide for every ten transformers the following mandatory spares:

• One HV Bushing,
• One LV Bushing,
• One complete set of bi-metallic connectors for bushings

The prices of mandatory spares will be taken into account in the evaluation of tenders.
The Bidder shall provide a list of recommended spare parts together with their individual prices. This list shall inter alia include a complete remote transformer control panel as specified in subclause 30.1 of this specification. This list shall identify all essential spares and consumable items for any recommended maintenance for a period of five years after commissioning.

The Purchaser may order all or any of the spare parts listed at the time of contract award and the spare parts so ordered shall be supplied as part of the definite works. The Purchaser may order additional spares at any time during the contract period at the rates stated in the contract document. A spare parts catalogue with price list shall be provided and this shall form part of the drawings and literature to be supplied.

The Bidder shall give an assurance that spare parts and consumable items will continue to be available through the life of the equipment, which shall be 25 years minimum. However, the Supplier shall give a minimum of 12 months notice in the event that the Supplier or any sub-suppliers plan to discontinue manufacture of any component used in this equipment.

Any spare apparatus, parts or tools shall be subject to the same specification, tests and conditions as similar material supplied under the definite work section of the contract. They shall be strictly interchangeable and suitable for use in place of the corresponding parts supplied with the plant and must be suitably marked and numbered for identification.

Spare parts shall be delivered suitably packed and treated for long periods in storage. Each pack shall be clearly and indelibly marked with its contents, including a designation number corresponding to the spare parts list in the operation and maintenance instructions.

A complete set of all the special tools, devices, slings or tackles required for the adjustment and maintenance of the equipment shall be supplied in the quantity listed in the Price Schedule. Each set of tools shall be mounted in a lockable cabinet. These shall also be provided under this contract. Eye bolts which have to be removed after use shall be accommodated in the cabinet.

10. PACKING AND SHIPPING

10.1. Packing

The equipment and any supporting structures are to be transported adequately sealed against water ingress. All accessories and spares shall be packed and securely clamped against movement in robust, wooden, non-returnable packing cases to ensure safe transit in rough terrain, cross-country road conditions and in heavy rains from the manufacturer's works to the work sites.

Equipment or material liable to deterioration by sea water, moisture, or ingress of foreign matter shall be totally sealed in strong polythene bags and those liable to deterioration due to condensation shall be protected by packs of silica gel or other approved desiccant.

All accessories shall be carefully packed so that they are fully protected during transport and handling operations and in storage. Internal surfaces of loose accessories shall be sealed by means of gaskets and blanking off plates. All parts liable to rust shall receive an anti-rusting coat and shall be suitably protected. It shall be the responsibility of the Supplier to make good any damage caused through insufficient packing.

Each packing case shall be indelibly marked, on two adjacent sides and on the top, with the following:
• individual serial number;
• purchaser's name;
• contract number;
• destination;
• a colour coded marking to indicate destination;
• supplier's name;
• name and address of supplier's agent in Orissa;
• description and numbers of contents;
• manufacturer’s name
• country of origin;
• case measurements;
• gross and net weights in kilograms; and
• all necessary slinging and stacking instructions.

Each crate or container shall be marked clearly on the outside of the case to show TOP and BOTTOM positions with appropriate signs to indicate where the mass is bearing and the correct positions for slings. All component parts which are separately transported shall have permanent identification marks to facilitate correct matching and assembly at site. Welded parts shall be marked before welding.

Six copies of each packing list shall be sent to the Purchaser prior to dispatching the equipment.

10.2. Shipping

The Supplier shall be responsible for the shipping of all plant and equipment supplied from abroad to the ports of entry and for the transport of all goods to the various specified destinations including customs clearance, offloading, warehousing and insurance.

The Supplier shall inform himself fully as to all relevant transport facilities and requirements and loading gauges and ensure that the equipment as packed for transport shall conform to these limitations. The Supplier shall also be responsible for verifying the access facilities specified.

The Supplier shall be responsible for the transportation of all loads associated with the contract works and shall take all reasonable steps to prevent any highways or bridges from being damaged by his traffic and shall select routes, choose and use vehicles and restrict and distribute loads so that the risk of damage shall be avoided. The Supplier shall immediately report to the Purchaser any claims made against the Supplier arising out of alleged damage to a highway or bridge.

All transport accessories, such as riding lugs, jacking pads or blanking off plates shall become the property of the Purchaser.

All items of equipment shall be securely clamped against movement to ensure safe transit from the manufacturer's facilities to the specified destinations.
The Supplier shall advise the storage requirements for any plant and equipment that may be delivered to the Purchaser's stores. The Supplier shall be required to accept responsibility for the advice given in so far as these arrangements may have a bearing on the behaviour of the equipment in subsequent service.

10.3. Hazardous substances

The Supplier shall submit safety data sheets for all hazardous substances used with the equipment. The Supplier shall give an assurance that there are no other substances classified as hazardous in the equipment supplied. No oil shall be supplied or used at any stage of manufacture or test without a certificate acceptable to the Purchaser that it has a PCB content of less than 2mg / kg. The Supplier shall accept responsibility for the disposal of such hazardous substances, should any be found.

The Supplier shall also be responsible for any injuries resulting from hazardous substances due to non compliance with these requirements.

11. SUBMITTALS

11.1. Submittals required with the bid

The following shall be required with each copy of the bid:

- completed technical data schedule;

- descriptive literature giving full technical details of equipment offered;

- outline dimension drawing for each major component, general arrangement drawing showing component layout and general schematic diagrams;

- type test certificates, where available, and sample routine test reports;

- detailed reference list of customers already using equipment offered during the last 5 years with particular emphasis on units of similar design and rating;

- details of manufacturer's quality assurance standards and programme and ISO 9000 series or equivalent national certification;

- deviations from this specification. Only deviations approved in writing before award of contract shall be accepted;

- list of recommended spare parts and consumable items for five years of operation with prices and spare parts catalogue with price list for future requirements.

11.2. Submittals required after contract award

11.2.1. Programme

Five copies of the programme for production and testing.
11.2.2. Technical Particulars

Within 30 days of contract award five bound folders with records of the technical particulars relating to the equipment. Each folder shall contain the following information:

- general description of the equipment and all components, including brochures;
- technical data schedule, with approved revisions;
- calculations to substantiate choice of electrical, structural, mechanical component size/ratings;
- detailed dimension drawing for all components, general arrangement drawing showing detailed component layout and detailed schematic and wiring drawings for all components;
- detailed loading drawing to enable the Purchaser to design and construct foundations for the transformer;
- statement drawing attention to all exposed points in the equipment at which copper/aluminium or aluminium alloy parts are in contact with or in close proximity to other metals and stating clearly what protection is employed to prevent corrosion at each point;
- detailed installation and commissioning instructions;

At the final hold point for Purchaser approval prior to delivery of the equipment the following shall be submitted:

- inspection and test reports carried out in the manufacturer's works;
- operation and maintenance instructions as well as trouble shooting charts.

11.2.3. Operation and Maintenance instructions

A copy of installation and commissioning instructions and of the operation and maintenance instructions and trouble shooting charts shall be supplied with each transformer.

11.3. Drawings

Within 30 days of contract commencement the Supplier shall submit, for approval by the Purchaser, a schedule of the drawings to be produced detailing which are to be submitted for “Approval” and which are to be submitted “For Information Only”. The schedule shall also provide a programme of drawing submission, for approval by the Purchaser, that ensures that all drawings and calculations are submitted within the period specified above.

All detail drawings submitted for approval shall be to scale not less than 1:20. All important dimensions shall be given and the material of which each part is to be constructed shall be indicated on the drawings. All documents and drawings shall be submitted in accordance with the provisions of this specification and shall become the property of the Purchaser.

All drawings and calculations, submitted to the Purchaser, shall be on international standard size paper, either A0, A1, A2, A3 or A4. All such drawings and calculations shall be provided with a contract title block, which shall include the name of the Purchaser and
Consultants and shall be assigned a unique project drawing number; the contract title block and project numbering system shall be agreed with the Purchaser.

Script sizes and thickness of scripts and lines be selected so that if reduced by two stages the alphanumeric characters and lines are still perfectly legible so as to facilitate microfilming.

For presentation of design drawings and circuit documents IEC Publication 617 or equivalent standards for graphical symbols are to be followed.

12. **APPROVAL PROCEDURE**

The Supplier shall submit all drawings, documents and type test reports for approval in sufficient time to permit modifications to be made if such are deemed necessary and re-submit them for approval without delaying the initial deliveries or completion of the contract work. The Purchaser’s representative shall endeavour to return them within a period of four weeks from the date of receipt.

Three copies of all drawings shall be submitted for approval and three copies for any subsequent revision. The Purchaser reserves the right to request any further additional information that may be considered necessary in order to fully review the drawings. If the Purchaser is satisfied with the drawing, one copy will be returned to the Supplier marked with “Approved” stamp. If the Purchaser is not totally satisfied with the drawing, then “Approved Subject to Comment” status will be given to it and a comment sheet will be sent to the Supplier. If the drawing submitted does not comply with the requirements of the specification then it will be given “Not Approved” status and a comment sheet will be sent to the Supplier. In both these cases the Supplier will have to modify the drawing, update the revision column and resubmit for final Approval. Following approval, twenty copies of the final drawings will be required by the Purchaser.

Any drawing or document submitted for information only should be indicated as such by the Supplier. Drawings and documents submitted for information only will not be returned to the Supplier unless the Purchaser considers that such drawing needs to be approved, in which case they will be returned suitably stamped with comments.

The Supplier shall be responsible for any discrepancies or errors in or omissions from the drawings, whether such drawings have been approved or not by the Purchaser. Approval given by the Purchaser to any drawing shall not relieve the Supplier from his liability to complete contract works in accordance with this specification and the condition of contract nor exonerate him from any of his guarantees.

If the Supplier needs approval of any drawing within a period of less than four weeks in order to avoid delay in the completion of supply, he shall advise the Purchaser when submitting the drawings and provide an explanation of the document’s late submission. The Purchaser will endeavour to comply with the Contractors timescale, but this cannot be guaranteed.

13. **SURFACE TREATMENT**

A full description of the corrosion prevention system proposed by the Bidder shall be given in the Schedule and this is subject to acceptance by the Purchaser. This description shall include details of surface preparation, rust inhibition, paint thickness, treatment of fasteners and painting of surfaces in contact with oil.
All machining, drilling, welding, engraving, scribing or other manufacturing activities which would damage the final surface treatment shall be completed before the specified surface treatment is carried out. Any subsequent damage occurring to the surface treatment up to the final delivery and offloading shall be made good by the Supplier.

13.1. Painting

All paints shall be applied on clean, dry surfaces under suitable atmospheric and other conditions in accordance with the paint manufacturer’s instructions. All paints used shall be compatible with each other and capable of being used as a system. The system shall be capable of performance for five years in the environment specified without any need for maintenance.

No consecutive coats of paint shall be of the same shade.

The minimum standards acceptable are:

- Cleaning by shot blasting to Grade Sa 2.5 of ISO 8501-1.
- All sheet steelwork shall be degreased, pickled and phosphated in accordance with IS 6005 - “Code of Practice for phosphating of iron and steel.”
- All rough surfaces of coatings shall be filled with an approved two pack filler and rubbed down to a smooth finish.
- Interior surfaces of mechanism chambers, boxes and kiosks, after preparation, cleaning and priming shall be painted with one coat of zinc chromate primer, one coat of phenolic based undercoating, followed by one coat of phenolic based finishing paint to white colour followed by a final coat of anti-condensation white paint of a type and make to the approval of the Purchaser. A minimum overall paint film thickness of 150 microns shall be maintained throughout.
- Exterior steel work and metalwork, after preparation and priming shall be painted with one coat of zinc chromate primer, one coat of phenolic based under coating and two coats of micaceous iron oxide paint, then painted with a final coat of phenolic based hard gloss finishing paint of the Light Grey Shade No 631 of IS 5, to provide an overall minimum paint thickness of 200 microns.

13.2. Galvanising

All galvanising shall be carried out by the hot dip process, in accordance with Specification ISO 1460 or IS 2629. However, high tensile steel nuts, bolts and spring washers shall be electro galvanised to service condition 4. The zinc coating shall be smooth, continuous and uniform. It shall be free from acid spots and shall not scale, blister or be removable by handling or packing. There shall be no impurities in the zinc or additives to the galvanic bath which could have a detrimental effect on the durability of the zinc coating.

Before pickling, all welding, drilling, cutting, grinding etc. must be completed and all grease, paint, varnish, oil, welding slag etc. completely removed. All protuberances which would affect the life of galvanising shall also be removed.

The weight of zinc deposited shall be in accordance with that stated in standard BS 729, ISO1460 or IS2629 and shall be not less than 0.61 kg/sq. mtr with minimum thickness of 86 microns for items of thickness more than 5 mm, 0.46 kg/ sq. mtr. (64 microns) for items of
thickness between 2 mm & 5 mm and 0.33 kg/ sq. mtr (47 microns) for items less than 2 mm thick.

Parts shall not be galvanised if their shapes are such that the pickling solution cannot be removed with certainty or if galvanising would be unsatisfactory or if their mechanical strength would be reduced. Surfaces in contact with oil shall not be galvanised unless they are subsequently coated with an oil resistant varnish or paint.

In the event of damage to the galvanising the method used for repair shall be subject to the approval of the Purchaser or that of his representative.

Repair of galvanising on site will generally not be permitted.

The threads of all galvanised bolts and screwed rods shall be cleared of spelter by spinning or brushing. A die shall not be used for cleaning the threads unless specifically approved by the Purchaser. All nuts shall be galvanised with the exception of the threads which shall be oiled.

Partial immersion of the work shall not be permitted and the galvanising tank must therefore be sufficiently large to permit galvanising to be carried out by one immersion.

After galvanising no drilling or welding shall be performed on the galvanised parts of the equipment excepting that nuts may be threaded after galvanising. To avoid the formation of white rust, galvanised material shall be stacked during transport and stored in such a manner as to permit adequate ventilation. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanisation.

The galvanised steel shall be subjected to test as per IS-2633.

14. FASTENERS

All bolts, studs, screw threads, pipe threads, bolt heads and nuts shall comply with the appropriate Indian Standards for metric threads, or the technical equivalent.

Bolts or studs shall not be less than 6 mm in diameter except when used for small wiring terminals.

All nuts and pins shall be adequately locked.

Wherever possible bolts shall be fitted in such a manner that in the event of failure of locking resulting in the nuts working loose and falling off, the bolt will remain in position.

All ferrous bolts, nuts and washers placed in outdoor positions shall be treated to prevent corrosion by hot dip galvanising except high tensile steel bolts and spring washers which shall be electro-galvanised to service condition four. Appropriate precautions shall be taken to prevent electrolytic action between dissimilar metals.

Where bolts are used on external horizontal surfaces and where water can collect, methods of preventing the ingress of moisture to the threads shall be provided.

Each bolt or stud shall project at least one thread but not more than three threads through the nut, except when otherwise approved for terminal board studs or relay stems. If bolts nuts are placed so that they are inaccessible by means of ordinary spanners, special spanners shall be provided.

The length of the screwed portion of the bolts shall be such that no screw thread may form part of a shear plane between members.

Taper washers shall be provided where necessary.
Protective washers of suitable material shall be provided front and back on the securing screws.

15. COMPLETENESS OF CONTRACT

All fittings or accessories, although not specifically mentioned herein, but necessary or usual for similar equipment and their efficient performance shall be provided by the supplier without extra charges. The tender shall clearly indicate if any additional equipment or parts would be necessary to give a complete offer and if so, the details and the prices shall be included in the bid.

16. PADLOCKS

The Supplier shall provide padlockable handles and non-ferrous padlocks with duplicate keys for the local Transformer tap change control panel, mechanism box or kiosk doors to prevent all unauthorised access and operation.

17. LABELS

All apparatus shall be clearly labelled indicating, where necessary, its purpose and service positions.

The material of all labels and plates, their dimensions, legend and the method of printing shall be subject to approval of the Purchaser. The surfaces of all labels and plates shall have a mat or satin finish to avoid dazzle from reflected light.

Colours shall be permanent and free from fading. Labels mounted on black surfaces shall have white lettering. Danger plates shall have white lettering on a red background.

All labels and plates for outdoor use shall be of incorrodible material. Where the use of enamelled iron plates is approved, the whole surface including the back and edges, shall be properly covered and resistant to corrosion.

They shall be engraved in English. Name plates shall be white with black engraved lettering and shall carry all the applicable information specified in the applicable items of the Standards.

No scratching, corrections or changes will be allowed on name plates.

Name plates shall be provided of white background with black engraved lettering carrying all the applicable information specified in the standards and other details as required by the Purchaser. The name plate inscription and the size and lettering shall be submitted to the Purchaser for approval.

18. OPERATIONAL TRAINING

Not applicable.
PART 2: TECHNICAL

19. TYPE OF TRANSFORMER

The transformers shall be double copper wound, three phase, oil immersed, 33/11kV, 50 Hz with on-load tap-changer with 8.00 MVA Transformer only & off-load tap-changer for others mounted in the high voltage end.

The transformers shall be naturally cooled, Type ONAN.

20. RATED CAPACITY

The MVA ratings shall be 3.15 MVA, 5 MVA and 8 MVA based on natural cooling. Each transformer shall be capable of supplying its rated power continuously at all tap positions with rated voltage on the low voltage winding. The transformers shall also be capable of delivering rated current at an applied voltage equal to 105% of the rated voltage.

Each transformer shall be capable of supplying its rated power continuously under ambient temperature conditions without the temperature rise of the top oil exceeding 50°C and without the temperature rise of the windings as measured by resistance exceeding 55°C. The ambient temperature conditions are as follows:

- Maximum ambient temperature: 50°C
- Maximum daily average ambient temperature: 35°C
- Maximum yearly weighted average ambient temperature: 32°C

The transformer may be overloaded during emergency up to 150% of its continuous rating in accordance with IEC Publication 354 or IS 6600. Bushings, tap changer and other current-carrying parts shall also be designed for this condition.

21. VOLTAGE RATIO

Each transformer shall be supplied with an on load tap changer (as specified) connected to the high voltage winding. The tap changer shall have 17 tap positions and shall be so arranged as to give variations of transformation ratio in equal steps of 1.25% per step. The total range of the tapchanger shall be from +5.0 percent to -15.0 percent. Tap 5 shall be the principal tap and the transformation ratio at tap 5 shall be 33.00 KV to 11.00 KV.

The no-load voltage ratios shall be as follows:

<table>
<thead>
<tr>
<th>Tap No.</th>
<th>High Voltage</th>
<th>Low Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34.65kV</td>
<td>11.0kV</td>
</tr>
<tr>
<td>5</td>
<td>33.00kV</td>
<td>11.0kV</td>
</tr>
<tr>
<td>17</td>
<td>28.05kV</td>
<td>11.0kV</td>
</tr>
</tbody>
</table>
22. **WINDING CONNECTIONS AND VECTOR GROUP**

The transformers shall be connected in accordance with IEC Publication 76 or IS 2026 as follows:

- **HV Winding**: Delta connected.
- **LV Winding**: Star connected.
- **Vector Group**: Dyn 11

23. **INSULATION LEVELS**

The transformers shall be designed and tested to the following insulation levels:

<table>
<thead>
<tr>
<th>Line Terminals</th>
<th>Power Frequency Voltage (rms.)</th>
<th>Lightning Impulse Voltage (peak)</th>
</tr>
</thead>
<tbody>
<tr>
<td>33kV</td>
<td>70kV</td>
<td>170kV (1.2/50 µsec.)</td>
</tr>
<tr>
<td>11kV</td>
<td>28kV</td>
<td>75kV (1.2/50 µsec.)</td>
</tr>
</tbody>
</table>

The windings shall be uniformly insulated and the low voltage neutral point shall be insulated for full voltage.

24. **IMPEDANCE VOLTAGE**

The impedance on the principal tap (Tap 3) shall be as follows:

- 3.15 MVA - 6.25%
- 5 MVA - 7.15%
- 8 MVA - 8.35%

The impedance voltage refers to the principal tapping. No negative tolerance on this percentage impedance is allowed. A positive tolerance of +10% is allowed as per IEC 76 / IS 2026.

Transformers of each rating shall have corresponding impedance per tap characteristics such that transformers of the same rating can be operated in parallel.
25. **SHORT CIRCUIT PERFORMANCE**

The transformer shall be capable of withstanding the thermal and dynamic effects of short circuits, as specified in IEC 76-5 ‘Ability to withstand short circuits’.

Each transformer shall be capable of withstanding for 2 seconds a bolted metallic short circuit on the terminals of either winding with rated voltage on the other winding and the tap-changer in any position.

If short circuit tests have been carried out on the particular design of transformer offered, the test results shall be supplied with the bid.

26. **REGULATION**

The regulation of each transformer from no-load to continuous rated output at 1.0 power factor and at 0.85 lagging power factor shall be as guaranteed in the Technical Data Schedules.

27. **FLUX DENSITY**

Each transformer shall be capable of operating continuously with rated current and with system maximum voltage applied to the low voltage winding at a frequency of 96 per cent of rated frequency without exceeding the temperature rise specified in Clause 20.

The limit of flux density at normal voltage and frequency shall be subject to the requirements for losses, harmonics and noise suppression but in any event shall not exceed 1.6 Tesla.

The transformer core shall not be saturated at maximum system voltage i.e. 36.3kV.

28. **HARMONIC CURRENTS**

The transformers shall be designed with particular attention to the suppression of harmonic voltages, especially the 3rd, 5th and 7th harmonics, so as to eliminate wave form distortion and the possibility of high frequency disturbances, induction effect or of circulating current between neutral points at different transformer stations.

29. **PARTIAL DISCHARGE**

Each transformer shall be partial discharge free up to 120% of rated voltage as the voltage is reduced from 150% of rated voltage i.e. there shall be no significant rise above background level.

30. **ON-LOAD TAP-CHANGERS WITH REMOTE TAP CHANGE CONTROL**

Only transformer of capacity 8.00 MVA shall be provided with an on-load tap-changer connected to the high voltage winding. The on-load tap-changer shall be capable of
withstanding the voltages described in Clause 23 and shall comply with the requirements of IEC 214, latest revision.

Its tapping range, number of steps and tap positions shall be as specified in Clause 21.

Adequate access for personnel shall be provided for inspection and maintenance. The guaranteed interval between maintenance periods for the diverter switch shall be 10 years or 50,000 operations. It shall not be possible for oil in the diverter switch compartment to come in contact with the oil in the main transformer tank.

The tap-changer shall be driven by a motor operated mechanism incorporating a stored energy device which shall ensure that once a change of tap begins it is completed and so shall ensure that the mechanism does not fail in an intermediate position on loss of the supply voltage to the motor. The motor shall be rated for 400/230V, 50 Hz and shall operate satisfactorily at any voltage between 85% and 110% of rated voltage.

A tap-changer mechanism box with hinged door and mounted on the transformer tank at a convenient height shall contain all electrical and mechanical parts associated locally with control of the tap-changer. Remote tap-changer controls shall also be provided at a transformer tap change control panel (one per transformer, to be supplied under this contract) in the control room.

Facilities for electrical raise and lower operation (control switch or push button) as well as mechanical operation shall be provided at the tap-change mechanism box. An interlock shall be provided which shall interrupt the electric supply to the drive motor when the manual mechanical operating device is engaged. The motor drive control shall be such that on initiation of a tap-change operation by means of a control switch or push-button the tap-changer shall complete its movement from one service position to an adjacent one irrespective of whether or not the control switch or push-button has been operated continuously during the running time of the motor drive. Another operation shall only be possible when the previous operation has been completed, the control switch or push-button has been released and the control system is again in the rest position.

The tap-changer arrangement shall be such that a command to raise tap-numbers shall result in an increase in the secondary voltage with constant voltage applied to the high voltage winding.

An under and overvoltage monitoring relay fed with line voltage from the owner’s voltage transformers on the low voltage side of the transformer and capable of being set in a continuously variable range from 90% to 115% normal voltage (110V) shall be used to give visual and audible signals at the Transformer tap change control panel if the LV voltage lies above or below preset values.

Limit switches shall be provided to prevent over-running of the tap-change mechanism. These shall be directly connected in the motor circuit. In addition mechanical end stops shall be fitted to prevent over-running of the mechanism under any conditions. A counter shall be provided to indicate the number of tap-change operations that have taken place.

A mechanical tap-position indicator shall be provided and it shall be visible from ground level through a window in the door of the mechanism box. Position transmitters e.g. dial switches shall be provided to:

1. signal tap position to the Transformer tap change control panel in the control room.

2. signal "out of step" under parallel operating conditions.
A Remote/Local switch shall be provided at the mechanism box to select either remote or local operation. When this switch is turned to the Remote position control shall be passed to the Transformer tap change control panel in the control room. It should be possible to use only one control, i.e. Local or Remote.

It shall be possible to operate a transformer tap-changer independently or in parallel with the tap-changers of other similar transformers in the same substation in either a "master" or "follower" mode. In addition, when operating independently or in parallel in the master mode, it shall be possible to have manual operation by means of control switch, push button or, (in future) automatic operation by means of an automatic voltage regulating relay. Contacts shall be provided for future SCADA control of the tap-changer and for reporting of the tap position and mode of control to the SCADA system.

The paralleling scheme shall use the in step principle and shall have provision for operating singly or in parallel in any combination. It shall be possible for any transformer in a group to be selected as either the master or follower for that group when operating in parallel. Each transformer tap change control panel shall therefore have a manual/automatic control switch or push buttons, independent/master/follower control switch or push buttons as well as "raise" and "lower" control switches or push buttons. Interlock shall be provided to avoid independent operation when the transformers are running in parallel. There should not be any out-of-step during such operation.

The control scheme shall be capable of extension to cater for the total number of transformers to be installed in any future development of the substation. The control mode selected shall be indicated on the front of the Transformer tap change control panel.

Each transformer shall have a miniature circuit breaker (MCB) on the AC distribution cabinet through which the 400/230V, 50 Hz supply to its tap-changer and temperature controls is passed. Separate MCB's shall be provided at the mechanism box for protection of the motor and control circuits. The control circuits shall operate at 110V single phase, to be supplied from a transformer having a ratio of 230 / 55-0-55 V, with the centre point earthed through a removable link mounted in the marshalling box or tapchanger mechanism box.

Each tap-changer mechanism box shall be fitted with an anti-condensation space heater (230V AC) controlled by a humidistat with variable range. A lamp for illumination purposes controlled by a door switch shall be provided. Solar gain can give rise to high temperature within a mechanism box. Adequate ventilation shall be provided to ensure that all equipment contained therein shall operate satisfactorily under these conditions.

A terminal block with terminals rated for 10A continuous current, 650V grade of moulded insulating materials shall be provided for panel wiring and external connections. Ten percent spare terminals shall be provided in each mechanism box.

The tap changer mechanism box shall be outdoor, weatherproof type, dust, vermin and damp proof with a degree of protection of IP54 of IEC 529 or IS 13947 equivalent.

30.1. Transformer Tap Change Control Panel

The indoor panel suitable for installation in the owner’s control room mentioned above shall contain:

- Raise and Lower pushbuttons or switch,
• Independent/Master/Follower selector switch,

• Remote tap position indicator.

• Necessary audible and visual alarms.

• Out-of-Step relay with two spare contacts (2 NO and 2 NC),

In addition to the above, the Transformer tap change control panel shall have an audible and visual annunciation system for the following trips and alarms:

- Oil temperature alarm
- Oil temperature trip
- Winding temperature alarm
- Winding temperature trip
- Buchholz alarm
- Buchholz trip
- Surge relay trip (OLTC gear)
- Low oil level alarm
- Tap changer out-of-step alarm
- Failure of DC supply alarm

Two spare windows shall be supplied on each panel.

Indicating lamps shall be panel mounted type with rear terminal connection. Lamps shall be provided with series connected resistors preferably built within the lamp assembly. Lamps shall have screwed translucent lamp covers to diffuse light and shall be continuously rated for 120% of 24 volt DC supply. The DC supply failure lamp shall operate from the AC supply and be rated for 230 volt AC. The wattage of the lamps shall be not more than 5 watts bulbs and lenses shall be interchangeably and easily replicable from the front of the panel.

The annunciation scheme for the facia windows and alarm bells shall work as follows:

<table>
<thead>
<tr>
<th>Incident</th>
<th>Alarm Bell</th>
<th>Facia Window</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident Alarm Bell</td>
<td>Ringing</td>
<td>Light Flashing</td>
</tr>
<tr>
<td>Fault Occurrence</td>
<td>Off</td>
<td>Light Flashing</td>
</tr>
<tr>
<td>Sound Cancel</td>
<td>Off</td>
<td>Steady Light</td>
</tr>
<tr>
<td>Acknowledge</td>
<td>Off</td>
<td>Clear</td>
</tr>
<tr>
<td>lamps cleared and reset</td>
<td>Off</td>
<td>Clear</td>
</tr>
<tr>
<td>Lamp Test</td>
<td>Off</td>
<td>Steady</td>
</tr>
</tbody>
</table>

Any new annunciation operating after the operation of the sound cancel shall cause audible and visual alarm even if the process of acknowledging the previous alarm is going on or has yet to be carried out. Resetting facilities for the flasher and audible alarm circuits of the annunciators shall be provided, and provision shall be made for switching of the entire annunciation system. Two spare windows shall be provided.
The control and rely panels shall be metal clad, dust, moisture, rodent and vermin proof with degree of protection not less than IP 41 specified in IEC 529/ IS 13947. Panel shall have folded construction and be of unit type. Each panel shall be a free standing structure, in depended floor mounting type and shall be manufactured from cold rolled sheet steel of thickness not less than 2.5 mm. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation, installation and service. The panel shall be painted as specified in the clause on painting in the specification.

Design, material selection and workmanship shall be such as to result in neat appearance inside and outside with no welds, rivets or bolt ends apparent from outside, with all exterior surfaces even and smooth. The equipment on the front of the panel shall be matched to give neat and uniform appearance.

All doors and removable covers shall be gasketed all around with neoprene bonded gaskets. Ventilating louvers shall be provided with screens and filters. The screen shall be made of non-corroding metal like brass or galvanised iron wire mesh.

Transformer tap change control panel shall be supplied with all necessary internal wiring, terminal blocks, relays and alarms to provide the above listed alarm and trip functions.

External wiring from the transformers to the panel and from the panel to the circuit breaker is not included in the scope of supply.

Panel wiring shall be suitably bunched and clamped for neat appearance. The conductors used for wiring purpose shall be PVC insulated 650 V grade semi flexible heat resistant, flame retardant and vermin proof electrolytic copper cable confirming to IEC 227 or IS 1554. The wiring shall be securely supported and taken through PVC troughs. All panel wiring shall be capable of withstanding a voltage of 2 KV AC, 50 Hz for 1 minute.

Terminal blocks of brass studs rated for 10 amps continuous current, 650 volts DC grade covered by moulded insulating material with adequate electrical clearance shall be provided for terminating the panel wiring and outgoing connections. The termination shall be made by crimping lugs or bare conductor with insulating sleeves at the end. The arrangement can be horizontal or vertical as per the standard practice adopted by the manufacturers. All terminal must be numbered and wire terminations provided with numbered ferrules for identification. All numbering and marking including those in wiring diagrams shall follow the guidelines provided in IS 11353. 10% spare terminals shall be provided.

31. COOLING AND TEMPERATURE CONTROL

The banks of cooling radiators shall be detachable from the tank for transport and maintenance. Shut-off valves shall be provided on the tanks of the transformers for this purpose. An air-vent and draining plug shall be provided on each radiator bank. All external surfaces of the radiators shall be hot dip galvanised as specified in Sub-clause 13.2, Part 1 of this document.

Temperature control equipment shall be housed in a local control box mounted on the side of the transformer. A 150mm diameter dial thermometer shall be provided to indicate the temperature of the top oil in the transformer. This thermometer shall be fitted in such a way that it can easily be read from ground level through a window in the door of the control box. The thermometer
shall be fitted with two adjustable contacts, one connected to give an alarm and one to trip associated circuit breakers. It shall also be fitted with a maximum temperature pointer which shall be re-settable by hand.

A similar dial thermometer shall be provided in the control box to indicate winding temperature. This thermometer shall have two sets of adjustable contacts one connected to give an alarm and the other to trip associated circuit breakers and a maximum temperature pointer which shall be re-settable by hand. The minimum range of these contacts shall be 50°C to 100°C for alarm and 60°C to 120°C for trip.

The temperature control box shall be weatherproofed to IP55 of IEC 529 or IS 2147 equivalent. Each box shall have a hinged gasketed door lockable by padlock. Solar gain can give rise to high temperature in a local control box. Adequate ventilation shall be provided to ensure that all equipment contained therein shall operate satisfactorily under these conditions.

A terminal block with 10% spare terminals shall be provided in each temperature control box.

32. TANK AND ACCESSORIES

General
The transformer tank shall be skid mounted type.

The transformer tank shall be designed so that the complete transformer with oil and excluding conservator and radiators can be lifted and transported without permanent deformation or oil leakage.

The tank and cover including the stiffeners shall be designed in such a manner as to leave no external pockets in which water can lodge, or internal pockets where gas/air can collect. All fittings shall be designed so as to prevent entry of air or leakage of oil from the tank.

All pipes, shall be externally welded to the tank wall.

The tank and cover shall be of structural quality, weldable mild steel with a minimum thickness of 3mm. All welding shall be stress relieved. The requirement of post weld heat treatment of tank/ stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1.

The tank lid shall not be welded shut, but shall be secured by bolts and provided with suitable oil-tight gasket.

The tank is to withstand vacuum up to 500mm of mercury for 3.15 MVA, 5 MVA and 8 MVA transformers and any pressure of oil developed during operation conditions including short circuits.
The permanent deflection of flat plates after the vacuum has been released shall not exceed the following values:

<table>
<thead>
<tr>
<th>Horizontal length of flat plate (mm)</th>
<th>Permanent deflection (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to and including 750</td>
<td>5</td>
</tr>
<tr>
<td>751 to 1250</td>
<td>6.5</td>
</tr>
<tr>
<td>1251 to 1750</td>
<td>8</td>
</tr>
<tr>
<td>1751 to 2000</td>
<td>9.5</td>
</tr>
<tr>
<td>2001 to 2250</td>
<td>11</td>
</tr>
<tr>
<td>2251 to 2500</td>
<td>12.5</td>
</tr>
<tr>
<td>2501 to 3000</td>
<td>16</td>
</tr>
<tr>
<td>above 3000</td>
<td>19</td>
</tr>
</tbody>
</table>

**Surface Treatment**

The transformer tank and accessories shall be adequately protected against corrosion. The inside of the tank shall be painted with an approved oil resisting varnish. The outside of the tank shall be painted as specified in Sub-clause 13.1, Part 1 of this document. External surfaces of radiators shall be hot-dip galvanised as specified in Sub-clause 13.2, Part 1 of this document.

**Conservator Tank**

A conservator tank shall be provided of adequate capacity between lowest and highest visible levels to meet expansion of oil from 0°C to 100°C. A suitable oil level gauge shall be located on the tank so that it can be easily read from ground level. The gauge shall be graduated for temperatures of 0°C, +45°C and +90°C.

Each gauge shall be provided with contacts for separate low oil level alarm and trip signals. The conservator shall be fitted with a filling hole with cap and drain valve. It shall be inclined at about 5 degrees towards the drain valve. The pipe connecting the conservator to the main tank shall project 20mm above the bottom of the conservator for collection of impurities.

**Breather**

The conservator tank shall be fitted with a breather in which silica gel is the dehydrating agent. The breather shall be a moulded type transparent case of adequate size and so designed that:

- the passage of air through the silica gel does not give rise to any excess pressure rise;
- silica gel crystal of not less than 5mm. size is used;
- the silica gel is sealed from the external atmosphere by means of an oil seal;
- the moisture absorption indicated by a change in colour of the crystals can be easily observed from a distance;
- the breather mounting height facilitates maintenance from ground level without switching out the transformer.

**Explosion Vent or Pressure Relief Device**

An explosion vent or pressure relief device shall be provided to release any severe build-up of pressure within the tank. The vent shall be designed such that in the event of an explosion, rain,
sand or any other foreign bodies are prevented from getting into the tank. The vent shall be positioned so as to direct the explosion safely into the oil pit.

**Oil Sampling Devices**

Oil sampling devices shall be fitted to the main tank. They shall be located suitably for easy access especially during maintenance, one near the bottom of the tank and one near the top.

**Oil Filtration**

Two 50mm bore filter valves shall be fitted to the tank, one on the top and the other diagonally opposite on the bottom.

**Lifting Lugs/Eyes**

Lifting lugs shall be provided for supporting the weight of the transformer including core and windings and fittings and with the tank filled with oil.

**Jacking Pads**

Four jacking pads shall be provided near the corners of the tank of each transformer and approximately 400mm above the lowest part of the tank. These pads shall be designed to take the complete weight of the transformer filled with oil.

**Hauling Eyes**

Hauling eyes shall be provided on all sides of the transformer.

**Earthing Terminals**

Earthing terminals shall be provided on the transformer close to each of the four corners of the tank to facilitate easy earthing of the transformer on site.

**Oil Valves**

In addition to the valves already mentioned, a drain valve shall be provided near the bottom of the tank. All oil valves shall be provided with means for securing them in the open or closed position.

33. **CORE AND WINDINGS**

33.1. **Core**

The core shall be constructed from high grade, non-ageing, cold rolled grain oriented silicon steel laminations or superior material.

The core and winding shall be capable of withstanding shocks during transport, installation and service. Provision shall be made to prevent movement of the core and windings relative to the tank during these conditions and also during short circuits.

The design shall avoid the presence of pockets which would prevent the complete emptying of the tank through the drain valve.

33.2. **Windings**

The winding conductor shall be of electrolytic copper. The insulation shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse. It shall be non catalytic and chemically inert in transformer oil during normal service.

The stacks of windings are to receive adequate shrinkage treatment.
The windings and connections are to be braced to withstand shocks during transport, switching, short circuit or other transient conditions.

34. **THERMOMETERS**

Thermometer pockets shall be provided on all transformer top covers with screwed top to avoid ingress of moisture.

35. **TRANSFORMER OIL**

The insulation oil shall be mineral oil to the IEC Standard 296 Class 1 or IS 335 whichever is more stringent. The complete first filling shall be of new oil free from inhibitors and additives. Transformers shall be shipped with oil filled at least to cover the core and coil assembly and the balance, with two percent extra quantity to cover spillage during filling to be supplied in non returnable steel drums.

36. **BUCHHOLZ AND GAS PRESSURE RELAYS**

A double float Buchholz relay shall be provided in the pipe connection from the main tank to the oil conservator. It shall be provided with isolating valves. The upper float of the Buchholz relay shall operate a contact to give an alarm on accumulation of gases caused by a gradual fault. The lower float shall operate a contact to make a circuit to trip associated circuit breakers in the event of further gas accumulation or a sudden flow of oil caused by an explosive development of gases.

The gas release connection from the Buchholz relay shall be brought down to a gas sampling device accessible from the ground to facilitate sampling with the transformer in service. The test connection from the Buchholz relay may be brought to the gas sampling device if suitable or may be terminated beside it. Isolating valves accessible from ground level shall be provided in both of these connections.

The gas sampling device shall have the following facilities:

1. Gas connection from the Buchholz relay through an isolating valve on the gas sampling device.
2. Coupling in the pipe connections to enable the device to be removed from the transformer.
3. Gas sampling valve at the top with outlet approximately 3mm diameter to make rubber tube connection. The outlet shall have a captive screwed cap.
4. Oil drain valve at the bottom with blanking plug.
5. The oil level in the device shall be visible from the front.

An oil surge relay shall be mounted in the pipe leading from the tap-changer head to the oil conservator. The relay shall be actuated by an oil flow caused by a tap-changer fault and its contact shall make a circuit to trip associated circuit breakers and provide annunciation in the control room.
37.  TERMINALS

Outdoor bushings shall be provided for the 33 KV and 11 KV terminations. The 11 KV termination shall include a neutral bushing of identical type and rating to the phase bushings. All bushing shall have a minimum creepage distance of 25 mm/KV. The protected creepage distance shall not be less than 50% of the total.

All bushings and terminations including the 11 KV neutral shall have a continuous current rating of 200% of the transformer rating and a 3 second short time rating equal to nominal short circuit current of the system.

Bushing shall be easily replaceable. Cemented in types will not be accepted. Bushing shall conform to IEC 137 and IEC 815/IS 3347 and IS 2099. They shall be sufficiently robust to withstand the normal transport and erection hazards.

33 KV bushing terminals shall be suitable for connection of AAAC conductor using a bimetallic connector. Bidders shall provide detailed drawing of the terminals with their bid.

11 KV bushing terminals shall be suitable for connection of multiple AAAC conductor using a bimetallic connectors. Bidders shall provide detailed drawing of the terminal with their bid.

Terminal Markings

The terminal markings shall be clearly and permanently shown. Painted markings are not acceptable. The windings shall be labelled as follows:

High Voltage : 3 phases and neutral U V W
Low Voltage : 3 phases and neutral u v w n

Terminals U, V, W and u, v, w shall be connected to phases R, Y, B, respectively.

38.  NOISE LEVEL AND RADIO INFLUENCE LEVEL

The noise level shall be guaranteed by the Supplier and measured in accordance with IEC 551. The guaranteed value shall be stated in the Technical Schedules and the measured noise level shall not exceed this value. Noise levels shall not exceed 52dB.

The maximum radio influence voltage shall be 250μV.

39.  LABELS AND RATING PLATES

Labels, plates, markings, and instructions shall be clear and indelible and in the English language. Cast-in or moulded-in words not in English shall be covered with a permanently fixed non-ferrous label inscribed in English.

A rating plate shall be provided in accordance with IEC Publication 76 / IS 2026. In addition a plate showing the location of all valves and air release cocks or plugs shall be provided.
40. **LOSS CAPITALISATION**

Transformer losses shall be capitalised at the following rates:

- Iron Loss: Rs 121,560 per kW
- Copper Loss: Rs 27,399 per kW

Losses will be capitalised at the above rates and added to the Bid Price for the purpose of comparing tenders.

The losses shall be measured during the routine tests. In the event of either the iron or copper loss exceeding its guaranteed value as stated in the Technical Data Schedules the relevant rate above shall be applied to the excess and the resulting amount shall be deducted from the Contract Price.

41. **TESTING**

**General**

Tests shall be carried out on transformers in accordance with IEC Publication 76 / IS 2026, IEC Publication 214 and as specified below.

Prices for type tests should be quoted as separate items.

41.1. **Type Tests**

The following shall be regarded as type tests.

(a) Test of temperature rise. This test shall be carried out on the tap having maximum losses.

(b) Measurements of open-circuit and short-circuit zero-sequence impedances of the HV and LV windings.

(c) Measurement of capacitances.

(d) Short circuit test.

(e) Impulse Test —

   (i) Full-wave impulse voltage withstand test. The test voltage shall be applied to each line and neutral terminal. The applied voltage shall be the relevant lightning impulse voltage specified in the clause on Insulation Levels.
(ii) Chopped-wave impulse voltage withstand test. The test voltage shall be applied to line terminals only. The applied voltage shall be 115% of the relevant lightning impulse voltage specified in the clause on Insulation Levels.

The test sequence to each terminal shall be as follows:

- One reduced full impulse (calibration)
- One 100% full impulse
- Two 115% chopped impulse
- Two 100% full impulse

(g) Noise level measurement, in accordance with IEC Publication 551 using a precision sound level meter conforming to IEC Publication 651. In addition the test shall be repeated with narrow band filters for the harmonic frequencies from 100Hz. up to 350 Hz.

(h) Vacuum test.

(i) Tap-changer tests required by IEC 214 as follows:
- temperature rise of contacts;
- switching tests;
- short-circuit current test;
- transition impedance test;
- mechanical tests;
- dielectric tests.

41.2. Routine Tests

The following shall be regarded as routine tests and shall be carried out on each transformer.

(a) Measurement of winding resistance at principal tap and two extreme taps.

(b) Voltage-ratio measurement and check of vector group.

(c) Measurement of the impedance voltage at principal tap and two extreme taps.

(d) Measurement of the load loss.

(e) Measurement of no-load loss and no-load current, including measurement of harmonics.

(f) Applied voltage test to all auxiliary circuits.

(g) Tests on on-load tap-changer (fully assembled on transformer).
(h) Induced over-voltage withstand test. The voltage applied shall be the relevant power frequency voltage specified in the clause on Insulation Levels.

(i) Separate source voltage withstand test. The applied voltage shall be the relevant power frequency voltage specified in the clause on Insulation Levels.

(j) Polarisation index test (1 minute and 10 minute). Index shall be not less than 1.5.

(i) Magnetic balance test.

41.3. Routine Test Sequence

The sequence of tests shall be:

(a) Winding resistance measurement, voltage ratio measurement and vector group check.

(b) Separate source voltage withstand test, induced over-voltage withstand test.

(c) Impedance voltage and loss measurements.

(d) Tapchanger test.

(e) Tests on auxiliary circuits.

The following tests on site will be carried out under a different contract after plant is fully assembled:

(a) Ratio and vector group checks.

(b) Insulation resistance (HV-LV, HV-E, LV-E).

(c) Oil tests.

(d) Other necessary pre-commissioning tests.

The Supplier will be held responsible for any discrepancy or defect discovered during these tests and shall rectify immediately on receipt of notification. The Supplier may at his own discretion witness site testing of transformers.

41.4. Rejection.

The purchaser may reject any transformer, if during testing and service the following is found:

(a) Load and/or no-load losses exceed the guaranteed value by 15% or more.

(b) Total losses exceed the guaranteed values by 10% or more.

(c) Impedance differs from the guaranteed value as specified.

(d) Transformer fails any test.

(e) Any deviation from specification is found not considered acceptable.
### PART 3 SCHEDULES

#### 42. TECHNICAL DATA SCHEDULE

(Please submit a separate schedule for each size of transformer)

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
<th>BIDDERS OFFER</th>
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<tbody>
<tr>
<td>1</td>
<td>33/11kV POWER TRANSFORMERS</td>
<td></td>
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<tr>
<td></td>
<td>Transformer Nominal Capacity</td>
<td>MVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GENERAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cross-sectional area of conductors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HV windings</td>
<td>mm²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- LV windings</td>
<td>mm²</td>
<td></td>
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<tr>
<td></td>
<td>Maximum current density in windings:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HV windings</td>
<td>A/ mm²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- LV windings</td>
<td>A/ mm²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zero sequence impedance, open circuit</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HV windings</td>
<td>Ohms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- LV windings</td>
<td>Ohms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zero sequence impedance, short circuit</td>
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<tr>
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<td>- HV windings</td>
<td>Ohms</td>
<td></td>
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<td>- LV windings</td>
<td>Ohms</td>
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<td></td>
<td>Magnetising current at rated voltage on principal tap</td>
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<tr>
<td></td>
<td>HV winding - Core</td>
<td>μF/ph</td>
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</tr>
<tr>
<td></td>
<td>LV winding - Core</td>
<td>μF/ph</td>
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</tr>
<tr>
<td></td>
<td>HV winding - LV winding</td>
<td>μF/ph</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total volume of oil</td>
<td>litres</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volume of oil above level of winding excluding conservator oil</td>
<td>litres</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight of core and windings</td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total weight of complete transformer ready for service -</td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight of transformer arranged for transport</td>
<td>kg</td>
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</tr>
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<td></td>
<td>Filling medium for transport</td>
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<td></td>
<td>Type of material used for gasket joints</td>
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<td>Vacuum withstand capability:</td>
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</tr>
<tr>
<td></td>
<td>- main tank</td>
<td>kPa</td>
<td></td>
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<td></td>
<td>- conservator</td>
<td>kPa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- tap-change compartment</td>
<td>kPa</td>
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<td></td>
<td>- radiators</td>
<td>kPa</td>
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</tr>
<tr>
<td></td>
<td>- width</td>
<td>mm</td>
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</tr>
<tr>
<td></td>
<td>- height</td>
<td>mm</td>
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</tr>
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<td>Dimensions as installed</td>
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</tr>
<tr>
<td></td>
<td>- length overall</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- width overall</td>
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<tr>
<td></td>
<td>- height overall</td>
<td>mm</td>
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<tr>
<td>2</td>
<td>STANDARDS</td>
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</tr>
<tr>
<td></td>
<td>In accordance with IEC 76 / IS 2026</td>
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<tr>
<td>3</td>
<td>TYPE</td>
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<td>Type</td>
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<tr>
<td>4</td>
<td>RATED POWER</td>
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<tr>
<td></td>
<td>Maximum continuous rating on all tap positions at specified service conditions.</td>
<td>MVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rating of windings:</td>
<td>MVA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HV</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- LV</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum winding hot spot temperature (ambient temperature 45°C)</td>
<td>°C</td>
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### Technical Data Schedule (Continued)

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<td>Maximum temperature rise in top oil:</td>
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<td>Maximum winding temperature rise measured by resistance:</td>
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<td><strong>VOLTAGE RATIO</strong></td>
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<td>No load voltage ratio:</td>
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<tr>
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<td>- Tap 1</td>
<td>kV</td>
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<td></td>
<td>- Tap 3</td>
<td>kV</td>
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</tr>
<tr>
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<td>- Tap 9</td>
<td>kV</td>
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<td><strong>WINDING CONNECTIONS AND VECTOR GROUP</strong></td>
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<td>Winding connections:</td>
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<td>- HV</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>- LV</td>
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</tr>
<tr>
<td></td>
<td>Vector Group</td>
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<td><strong>INSULATION LEVELS</strong></td>
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<td>Impulse withstand voltage:</td>
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<tr>
<td></td>
<td>- HV winding (1.2/50)</td>
<td>kV peak</td>
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<tr>
<td></td>
<td>- LV winding (1.2/50)</td>
<td>kV peak</td>
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<td>DESCRIPTION</td>
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<tr>
<td>8</td>
<td>- LV neutral</td>
<td>kV peak</td>
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<td></td>
<td>- Waveshapes for LV neutral</td>
<td>μs</td>
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<td>Power-frequency test voltage:</td>
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<tr>
<td></td>
<td>- HV winding</td>
<td>kV rms.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- LV winding</td>
<td>kV rms.</td>
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<tr>
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<td>- LV neutral</td>
<td>kV rms.</td>
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<td>IMPEDANCE VOLTAGE</td>
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<tr>
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<td>Impedance Voltage:</td>
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<tr>
<td></td>
<td>Tap 1</td>
<td>%</td>
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</tr>
<tr>
<td></td>
<td>Tap 3</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tap 9</td>
<td>%</td>
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<tr>
<td>9</td>
<td>SHORT CIRCUIT PERFORMANCE</td>
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<td></td>
<td>Short-circuit withstand capabilities</td>
<td>MVA 2 sec.</td>
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<td>10</td>
<td>REGULATION</td>
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<td>Regulation at full load (75°C) and unity power factor</td>
<td>%</td>
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</tr>
<tr>
<td></td>
<td>Regulation at full load (75°C) and 0.85 power factor lagging</td>
<td>%</td>
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## Technical Data Schedule (Continued)

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<tr>
<td>11</td>
<td>OVER-FLUXING</td>
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<tr>
<td></td>
<td>Maximum permissible overfluxing</td>
<td></td>
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<td></td>
<td>Volts/Hz in % of rated Volts/Hz:</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>for 1 min.</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for 30 mins.</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuously</td>
<td>%</td>
<td></td>
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<tr>
<td></td>
<td>Flux density at rated voltage on</td>
<td>Tesla</td>
<td></td>
</tr>
<tr>
<td></td>
<td>principal tap</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum flux. density in the</td>
<td>Tesla</td>
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</tr>
<tr>
<td></td>
<td>transformer.</td>
<td></td>
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<tr>
<td></td>
<td>State conditions under which it</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>occurs</td>
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<td>12</td>
<td>HARMONIC CURRENTS</td>
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<tr>
<td></td>
<td>3rd Harmonic as percentage of no</td>
<td>%</td>
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<td>load current</td>
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<td>5th Harmonic as percentage of no</td>
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<td>load current</td>
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<tr>
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<td>7th Harmonic as percentage of no</td>
<td>%</td>
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<td>load current</td>
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<td>13</td>
<td>PARTIAL DISCHARGE</td>
<td>pC</td>
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<td>Background level for partial</td>
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<td>discharge tests</td>
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<td>14</td>
<td>ON-LOAD TAP-CHANGER</td>
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<td>Tap Changer:</td>
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</tr>
<tr>
<td></td>
<td>- Manufacturer &amp; Type No.</td>
<td>Yes/No</td>
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<tr>
<td></td>
<td>- Located in HV winding</td>
<td>%</td>
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<tr>
<td></td>
<td>- Range as % of nominal voltage</td>
<td>Step</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Number of steps</td>
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<tr>
<td></td>
<td>- Impulse withstand level</td>
<td>kV</td>
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<tr>
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<td>- 50Hz voltage withstand level(1 minute)</td>
<td>kV</td>
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<td></td>
<td>- Tap-changer motor rating</td>
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<td>Maximum Current Rating</td>
<td>A</td>
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<td>Method of separating tap change selector switch from the main tank oil</td>
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<td>COOLING AND TEMPERATURE CONTROL</td>
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<td>Cooling:</td>
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<td></td>
<td>- radiators on main tank</td>
<td>Yes/No</td>
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<td>Number of radiators</td>
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<td></td>
<td>Surface area of each radiator</td>
<td>sq. m</td>
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<td>16</td>
<td>TANK AND ACCESSORIES</td>
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<td>16.1</td>
<td>SURFACE TREATMENT</td>
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<td>Method of surface treatment:</td>
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<td>- Tank</td>
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<td></td>
<td>- Radiators etc.</td>
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<td>TRANSFORMER OIL</td>
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<td>Manufacture and type of transformer oil</td>
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<td>18</td>
<td>TERMINALS</td>
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<td>BUSHINGS</td>
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<td>HV Bushings:</td>
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<td></td>
<td>- Manufacturer</td>
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<tr>
<td></td>
<td>- Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Total creepage distances to earth</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Protected creepage distance to earth</td>
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<tr>
<td></td>
<td>- Electrical clearance phase to phase</td>
<td>mm</td>
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<td>- Electrical clearance to earth</td>
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<td>- Rated current</td>
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<td>- Rated voltage</td>
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<td>- 1 min. 50Hz dry withstand voltage</td>
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<td>- 1 min. 50Hz wet withstand voltage</td>
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<td>- Impulse withstand voltage</td>
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<td>- Rated short-time current</td>
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<td>LV Bushings:</td>
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<td>- Manufacturer</td>
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<tr>
<td></td>
<td>- Type</td>
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<tr>
<td></td>
<td>- Total creepage distances to earth</td>
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<td></td>
<td>- Protected creepage distance to earth</td>
<td>mm</td>
<td></td>
</tr>
</tbody>
</table>
### Technical Data Schedule (Continued)

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
<th>BIDDERS OFFER</th>
</tr>
</thead>
</table>
| 18.2     | - Electrical clearance phase to phase  
- Electrical clearance to earth  
- Rated current  
- Rated voltage  
- 1 min. 50Hz dry withstand voltage  
- 1 min. 50Hz wet withstand voltage  
- Impulse withstand voltage  
- Rated short-time current (2 second) | mm  
mm  
A  
kV  
kV  
kV  
kA | |
| NEUTRAL TERMINALS | 11kV Neutral Bushing:  
- Manufacture  
- Type  
- Total creepage distances to earth  
- Protected creepage distance to earth  
- Electrical clearance to earth  
- Rate current  
- Rated voltage  
- 1 min. 50Hz dry withstand voltage  
- 1 min. 50Hz wet withstand voltage  
- Impulse withstand voltage  
- Rated short-time current (2 second) | mm  
mm  
mm  
A  
kV  
kV  
kV  
kA | |
| 19       | NOISE LEVEL | Guaranteed noise level in dB (A) to IEC 551: | dB(A) |
Technical Data Schedule (Continued)

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
<th>BIDDERS OFFER</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>INSTALLATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vibration characteristics of supports</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>GUARANTEED LOSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guaranteed no-load loss:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tap 1</td>
<td>kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tap 3</td>
<td>kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tap 9</td>
<td>kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guaranteed load loss: (75°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tap 1</td>
<td>kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tap 3</td>
<td>kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tap 9</td>
<td>kW</td>
<td></td>
</tr>
</tbody>
</table>
43. **NON COMPLIANCE SCHEDULE**

On this schedule the bidder shall provide a list of non compliances with this specification, documenting the effects that such non compliance is likely to have in the equipment's life and operating characteristics. Each non compliance shall be referred to the relevant specification clause.

Where there are no deviations from specifications, the bidder shall so indicate by stating "no deviations" in this schedule.

<table>
<thead>
<tr>
<th>Clause No</th>
<th>Non Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
44. TEST CERTIFICATES SCHEDULE

On this schedule a list of the test certificates included with the bid shall be provided. This list should include type test certificates and sample routine test reports. Each certificate listed shall be referred to the relevant specification clause and item of equipment to which the test applies.

<table>
<thead>
<tr>
<th>Clause No</th>
<th>Type Test Certificate or Routine Test Report</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. SCOPE

1.1. These specification cover the design, engineering, manufacturing, shop-testing, pre-delivery inspection, packing and forwarding, loading at manufacturer’s Works, transportation, transit insurance, supply, delivery and unloading, storing and handling at site, erection installation, testing and commissioning of 33/11KV Outdoor step down, ONAN cooled Power Transformers of different rating (3.15 MVA, 5 MVA, 8 MVA and 10 MVA) complete with all accessories/ fittings and spare parts as specified herein, to be used in the networks of CESU.

1.2. The equipment offered should have been successfully type tested and the design should have been in satisfactory operation for a period not less than three years as on the date of bid opening. Compliance shall be demonstrated by with the bid,

   i) authenticated copies of the type test reports and

   ii) performance certificates from the users, specifically from Central Govt./ State Govt. or their undertakings.

1.3. The scope of supply should also include the provision of type test. Rates of type tests shall be given in the appropriate price schedule of the bidding document and will be considered for evaluation. The D.D.G.M., APDRP reserves the right to waive type tests as indicated in the section on Quality Assurance, Inspection and Testing in this specification.

1.4. The Power Transformer shall conform in all respects to highest standards of engineering, design, workmanship, this specification and the latest revision of relevant standards at the time of offer and the D.D.G.M., APDRP shall have the power to reject any work or material, which, in his judgment, is not in full accordance therewith.

2. SPECIFIC TECHNICAL REQUIREMENTS

   1. Rated MVA (ONAN rating) 3.15MVA, 5MVA, 8MVA and 10MVA
   2. No. of phases 3
   3. Type of installation Outdoor
   4. Frequency 50Hz. (± 5%)
   5. Cooling medium Insulating Oil (ONAN)
   6. Type of mounting On Wheel, Mounted on rail
   7. Rated Voltage
      a) High Voltage winding 33KV
      b) Low Voltage winding 11KV
   8. Highest continuous system voltage
      a) Maximum system voltage ratio (HV/LV) 36KV / 12KV
      b) Rated voltage ratio (HV/LV) 36KV / 11KV
   9. No. of windings Two winding Transformers
   10. Type of cooling ONAN (Oil natural / Air natural)
   11. MVA Rating corresponding to ONAN 100%
   12. Method of connection:
      a) High Voltage (HV): Delta
      b) Low Voltage (LV): Star
   13. Connection symbol Dyn 11
   14. System earthing Neutral of LV side to be solidly earthed.
15. Percentage impedance voltage on normal tap and MVA base at 750°C corresponding to HV/LV rating and applicable tolerances:

<table>
<thead>
<tr>
<th>% Impedance</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 3.15 MVA 6.25</td>
<td>+10</td>
</tr>
<tr>
<td>b. 5.0 MVA 7.15</td>
<td>+10</td>
</tr>
<tr>
<td>c. 8.0 MVA 8.35</td>
<td>+10</td>
</tr>
<tr>
<td>d. 10.0 MVA 8.35</td>
<td>+10</td>
</tr>
</tbody>
</table>

16. Intended regular cyclic overloading of Windings:

As per IEC- 76-1, Clause 4.2

17. a) Anticipated unbalanced loading Around 10%
    b) Anticipated continuous loading of windings (HV / LV) 110% of rated current

18. a) Type of tape changer Off-load tap changer for all ratings
    b) Range of taping 5% to -10% in 6 equal steps of 2.5% each on HV winding.

19. Neutral terminal to be brought out On LV side only

20. Over Voltage operating capacity and duration 112.5% of rated voltage (continuous)

21. Maximum Flux Density in any part of the core and yoke at rated MVA, rated voltage i.e. 33KV / 11KV and system frequency of 50Hz. 1.6 Tesla

22. Insulation levels for windings:
    a) 1.2/50microsecond wave shape Impulse withstand (KVP)
    b) Power frequency voltage withstand (KV-rms)

23. Type of winding insulation
    a) HV winding Uniform
    b) LV winding Uniform

24. Withstand time for three phase short circuit 2 Seconds

25. Noise level at rated voltage and frequency As per NEMA publication No. TR-1.

26. Permissible Temperature Rise over ambient Temperature of 500°C
    a) Of top oil measured by thermometer 45 °C
    b) Of winding measured by resistance 50 °C

27. Minimum clearances in air (mm)

<table>
<thead>
<tr>
<th>Phase to Phase</th>
<th>Phase to ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) HV 350</td>
<td>320</td>
</tr>
<tr>
<td>b) LV 280</td>
<td>140</td>
</tr>
</tbody>
</table>
### 28. Terminals
- **HV winding line end**: 36 KV oil filled porcelain communicating type of bushings (Antiforg type)
- **LV winding**: 12 KV porcelain type of bushing (Antifog type)

### 29. Insulation level of bushing
- **HV**:
  - Lighting Impulse withstand (KVP): 170
  - 1 minute Power frequency withstand voltage (KV – rms): 70
  - Creepage distance (mm) (minimum): 900
- **LV**:
  - Lighting Impulse withstand (KVP): 75
  - 1 minute Power frequency withstand voltage (KV – rms): 28
  - Creepage distance (mm) (minimum): 300

### 30. Material of HV and LV Conductor
- Electrolytic copper

### 31. Accommodation on tank for outdoor neutral C.T. (For 8 MVA and 10 MVA transformers only)
- Yes

### 32. Neutral side C.T. for owner’s use:
- **Type**: Single phase out door mounted
- **Quantity**: One in LV side
- **Voltage class**: 12KV
- **No. of cores**: One
- **Current ratio(A/A)**: As per system requirement.
- **Turn Ratio**: Identical to the turns ratio, provided on HV and LV side
- **Knee point voltage**: 600 volts(min.)
- **Class of Accuracy**: P.S.
- **Maximum secondary winding resistance at 75°C**: 5 Ohms
- **Location for mounting station**: In neutral lead before connection to earth
- **Secondary of C.T.**: 1 (one amp.)

### 33. Maximum current density for HV and LV winding for rated current
- 2.8 A/mm²

### 34. Polarisation index i.e. ratio of megger values at 600sec. to 60sec. for HV to earth, LV to earth and HV to LV.
- Shall be greater than or equal to 1.5, but less than or equal to ‘5’.

### 35. Core Assembly
- Boltless type

### 36. Temperature Indicator
- **Oil**: One number
- **Winding**: One number

### 37. Maximum permissible no load at rated voltage and rated frequency.

<table>
<thead>
<tr>
<th>MVA</th>
<th>No Load (KW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.15</td>
<td>4.5</td>
</tr>
<tr>
<td>5.00</td>
<td>6.5</td>
</tr>
<tr>
<td>8.00</td>
<td>8.5</td>
</tr>
<tr>
<td>10.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>
38. Maximum permissible load loss at rated current and at 75°C

<table>
<thead>
<tr>
<th>MVA</th>
<th>Load Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.15</td>
<td>23.00 KW</td>
</tr>
<tr>
<td>5.00</td>
<td>34.00 KW</td>
</tr>
<tr>
<td>8.00</td>
<td>50.00 KW</td>
</tr>
<tr>
<td>10.00</td>
<td>57.00 KW</td>
</tr>
</tbody>
</table>

2.3. PERFORMANCE

i) Transformer shall be capable of withstanding for two seconds without damage to any external short circuit, with the short circuit MVA available at the terminals.

ii) The maximum flux density in any part of the core and yoke at rated MVA. Voltage and frequency shall be 1.6 Tesla (maximum).

iii) Transformer shall under exception circumstances due to sudden disconnection of the load, be capable of operating at the voltage approximately 25% above normal rated voltage for a period of not exceeding one minute and 40% above normal for a period of 5 seconds.

iv) The transformer may be operated continuously without danger on any particular tapping at the rated MVA ± 12.5% of the voltage corresponding to the tapping.

v) The thermal ability withstand short circuit shall be demonstrated by calculation.

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

2.4. AUXILIARY POWER SUPPLIES

The following power supplies shall be available at site:

i) AC 3-phase, 400 volts, 50Hz. Earthed

ii) AC 1-phase, 230 volts, 50Hz. Earthed

iii) 24 V DC.

2.5. DRAWINGS/ DOCUMENTS INCORPORATING THE FOLLOWING PARTICULARS SHALL BE SUBMITTED WITH THE BID

i) General outline drawing showing shipping dimensions and overall dimensions, net weights and shipping weights, quality of insulating oil, spacing of wheels in either direction of motions, location of coolers, marshalling box and tap changers etc.

ii) Assembly drawings of core, windings etc. and weights of main components/ parts.

iii) Height of center line on HV and LV connectors of transformers from the rail top level.

iv) Dimensions of the largest part to be transported.

v) GA drawings / details of various types of bushing

vi) Tap changing and Name Plate diagram

vii) Type test certificates of similar transformers.

viii) Illustrative and descriptive literature of the Transformer.

ix) Maintenance and Operating Instructions.

2.6. MISCELLANEOUS

i) Padlocks along with duplicate keys as asked for various values, marshalling box etc. shall be supplied by the contractor, wherever locking arrangement is provided.

ii) Foundation bolts for wheel locking devices of Transformer shall be supplied by the Contractor.
2.7. **DELIVERY**

The full quantity of the equipments shall be delivered, erected and commissioned at site on turnkey contract basis as per the delivery schedule appended to this specification.

2.8. **SCHEDULES**

All Schedules annexed to the specification shall be duly filled by the bidder separately.

2.9. **ALTITUDE FACTOR**

If the equipment is to be installed in the hilly area, 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.

2.10. **NAME PLATE**

Transformer rating plate shall contain the information as given in clause 15 of IS-2026 (part-1). The details on rating plate shall be finalized during the detailed engineering. Further, each transformer shall have inscription of purchaser’s name. The name plate shall also include (i) The short circuit rating, (ii) Measured no load current and no load losses at rated voltage and rated frequency, (iii) measured load losses at 75°C (normal tap only), (iv) D.C. resistance of each winding at 75°C.

3. **SERVICE CONDITIONS**

The service conditions shall be as follows

- Maximum a altitude above sea level: 1,000m
- Maximum ambient air temperature: 50°C.
- Maximum daily average ambient air temperature: 35°C.
- Minimum ambient air temperature: 5°C.
- Maximum temperature attainable by an object exposed to the sun: 60°C.
- Maximum yearly weighted average ambient temperature: 32°C.
- Maximum relative humidity: 100%
- Average number of thunderstorm day per annum (isokeraunic level): 70
- Average number of rainy days per annum: 120
- Average annual rainfall: 1500 mm.
- Maximum wind pressure: 260Kg./m²

Environmentally, the region where the equipment will be installed includes coastal areas, subject to high relative humidity, which can give rise to condensation. Onshore winds will frequently be salt laden. On occasions, the combination of salt and condensation may create pollution conditions for outdoor insulators.

Therefore, outdoor material and equipment shall be designed and protected for use in exposed, heavily polluted, salty, corrosive, tropical and humid coastal atmosphere.

4. **SYSTEM CONDITIONS**

The equipment shall be suitable for installation in supply systems of the following characteristics.

- Frequency
- Nominal system voltages
- Maximum system voltages: 33KV System 36.3KV
11KV System  12KV

- **Nominal short circuit level**
  - (Basing on apparent power)
  - 33KV System  31.3KV
  - 11KV System  13.1KV

- **Insulation levels:**
  - 33KV System  170KV(peak)
  - 1.2/50 µ sec impulse withstand voltage
  - 11KV System  75KV(peak)
  - Power frequency one minute withstand (wet 7 dry) voltage
  - 33KV System  70KV(rms)
  - 11KV System  28KV (rms)

- **Neutral earthing arrangements:**
  - 11 KV System  Solidly earthed

5. **CODES and STANDARDS**

5.1. (i) The design, material, fabrication, manufacture, inspection, testing before dispatch, erection, testing commissioning and performance of power transformers at site shall comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards and codes of practice. Nothing in this specification shall be constructed to relieve the Contractor of this responsibility.

5.2. The equipment and materials covered by this specification shall conform to the latest applicable provision of the following standards.

- **IS : 5** : Colour for ready mixed paints
- **IS : 325** : Three Phase induction Motors
- **IS : 335** : New insulating oil for transformers, switch gears
- **IS : 1271** : Classified of insulating materials for electrical machinery and apparatus in relation to their stability in services
- **IS : 2026(Part 1 to IV)** : Power Transformer
- **IS : 2071** : Method of high voltage testing
- **IS : 2099** : High voltage porcelain bushings
- **IS : 2147** : Degree of protection
- **IS : 2705** : Current transformers
- **IS : 3202** : Code of practice for climate proofing of electrical equipment
- **IS : 3347** : Dimension for porcelain transformer Bushings
- **IS : 3637** : Gas operated relays
- **IS : 5561** : Fitting and accessories for Power Transformers
- **IS : 5561** : Electric Power Connectors
- **IS : 6600/BS:CP’10:0** : Guide for loading of oil immersed Transformers
- **IS : 10028** : Code of practice for selection, installation and maintenance of transformers, Part. I, II and III
- **C.B.I.P. Publication** : Manual on Transformers

If the standard is not quoted for any item, it shall be presumed that the latest version of Indian Standard shall be applicable to that item.
The equipment complying other internationally accepted standards, may also be considered if they ensure performance superior to the Indian Standards.

5.3. DRAWINGS

a) The contractor shall furnish, within fifteen days after issuing of Letter of Award. Six copies each of the following drawings/documents incorporating the transformer rating for approval.

i) Detailed overall general arrangement 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 weight and shipping weights, crane lift for un-tanking, size of lugs and eyes, bushing lifting dimensions, clearances between HV and LV terminals and ground, quantity of insulating oil etc.

ii) Assembly drawings of core and winding and weights of main components / parts.

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

iv) GV drawings details of bushing and terminal connectors.

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

vi) Wheel locking arrangement drawings.

vii) Transportation dimensions drawings.

viii) Magnetization characteristic curves of PS class neutral and phase side current transformers if applicable.

ix) Interconnection diagrams.

x) Over fluxing withstand time characteristic of transformer.

xi) GA drawing of marshalling box.

xii) Control scheme/ wiring diagram of marshalling box.

xiii) Technical leaflets of major components and fittings.

xiv) A built drawings of schematics, wiring diagram etc.

xv) Setting of oil temperature indicator, winding temperature indicator.

xvi) Completed technical data sheets.

xvii) Details including write-up of tap changing gear.

xviii) HV conductor bushing.

xix) Bushing Assembly

xx) Bi-metallic connector suitable for connection to 100 mm² up to 232 mm² AAAC Conductor.

xxi) GA of LV cable Box.

xxii) Radiator type assembly.
b) All drawings, documents, technical data sheets and certificates, results calculations shall be furnished.

5.4. Any approval given to the detailed drawings by the purchaser shall not relieve the contractor of the responsibility for correctness of the drawing and in the manufacture of the equipment. The approval given by the purchaser shall be general with over all responsibility with contractor.

6. **GENERAL CONSTRUCTIONAL FEATURES**

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

6.2. Similar parts particularly removable ones shall be interchangeable.

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

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

6.5. Exposed parts shall not have pockets where water can collect.

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

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

6.8. Labels, indelibly marked, shall be provided for all identifiable accessories like Relays, switches current transformers etc. all label plates shall be of in corrodible material.

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

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

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

6.12. Schematic Drawing of the wiring, including external cables shall be put under the prospane sheet on the inside door of the transformer marshalling box.

6.13. **Painting**

6.13.1. All paints shall be applied in accordance with the paint manufacturer’s recommendations. Particular attention shall be paid to the following:

   a. Proper storage to avoid exposure as well as extremes of temperature.
   b. Surface preparation prior to painting.
   c. Mixing and thinning.
   d. Application of paints and the recommended limit on time intervals between coats.
   e. Shelf life for storage.
6.13.1.1. All paints, when applied in normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

6.13.1.2. All primers shall be well marked into the surface, particularly in areas where painting is evident, and the first priming coat shall be applied as soon as possible after cleaning. The paint shall be applied by airless spray according to the manufacturer’s recommendations. However, wherever airless spray is not possible, conventional spray be used with prior approval of purchaser.

6.13.1.3. The supplier shall, prior to painting project nameplates, lettering gauges, sight glassed, light fittings and similar such items.

6.13.2. Cleaning and Surface Preparation

6.13.2.1. After all machining, forming and welding has been completed, all steel work surfaces shall be thoroughly cleaned of rust, scale, welding slag or spatter and other contamination prior to any painting.

6.13.2.2. Steel surface shall be prepared by Sand/Shot blast Clean or Chemical cleaning by Seven tank process including Phosphating to the appropriate quality.

6.13.2.3. The pressure and Volume of the compressed air supply for the blast cleaning shall meet the work requirements and shall be sufficiently free from all water contamination prior to any painting.

6.13.2.4. Chipping, scraping and steel wire brushing using manual or power driven tools cannot remove firmly adherent mill-scale and shall only be used where blast cleaning is impractical.

6.13.3. Protective Coating

As soon as all items have been cleaned and within four hours of the subsequent drying, they shall be given suitable anticorrosion protection.

6.13.4. Paint Material

Followings are the type of paints that may be suitably used for the items to be painted at shop and supply of matching paint to site:

i) heat resistant paint (Hot oil proof) for inside surface.

ii) For external surfaces one coat of Thermo setting Paint or 2 coats of Zinc Chromate followed by 2 coats of Synthetic Enamel paint. The color of the finishing coats shall be dark admiral grey conforming to No.632 or IS 5:1961.

6.13.5. Painting Procedure

6.13.5.1. All painting shall be carried out in conformity with both specification and with the paint manufacture’s recommendations. All paints in any one particular system. Whether shop or site applied, shall originate from one paint manufacturer.

6.13.5.2. Particular attention shall be paid to the manufacture’s instructions on storage, mixing, thinning and pot life. The paint shall only be applied in the manner detailed by the manufacturer e.g. brush, roller, conventional or airless spray and shall be applied under the manufacturer’s recommended condition. Minimum and maximum time intervals between coats shall be closely followed.
6.13.5.3. All prepared steel surface should be primed before visible re-rusting occurs or within 4 hours whichever is sooner. Chemical treated steel surfaces shall be primed as soon as the surface is dry and while the surface is warm.

6.13.5.4. Where the quality of film is impaired by excess film thickness, (wrinkling, mud cracking or general softness) the supplier shall remove the unsatisfactory paint coatings and apply another. As a general rule, dry film thickness should not exceed the specified minimum dry film thickness by more than 25%. In all instances, where two or more coats of the same paints are specified, such coatings may or may not be of contrasting colors.

6.13.5.5. Paint applied to items that are not be painted, shall be removed at supplier’s expense, leaving the surface clean, un-stained and undamaged.

6.13.6. Damages to Paints Work

6.13.6.1. Any damage occurring to any part of the painting scheme shall be made good to the same standard of corrosion protection and appearance as that originally employed.

6.13.6.2. Any damaged paint work shall be made as follows:
   a) The damaged area, together with an area extending 25mm. around its boundary, shall be cleaned down to bare metal.

   b) A priming coat shall immediately applied, followed by a full paint finish equal to that originally applied and extending 50mm. around the perimeter of the originally damaged.

6.13.6.3. The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

6.13.7. Dry Film thickness

6.13.7.1. To the maximum extent practicable, the coats shall be applied as a continuous film of uniform thickness and free of pores. Over-spray, skips, runs, sags and drips should be avoided. The different coats may or may not be same color.

6.13.7.2. Each coat of paint shall allowed to hardened before the next is applied as per manufacture’s recommendations.

6.13.7.3. Particular attention must be paid to full film thickness at edges.

6.13.7.4. The requirement for the dry film thickness (DFT) of paint and the material to be used shall be as given below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Paint Type</th>
<th>Area to be painted</th>
<th>No. of Coats</th>
<th>Total Dry film Thickness (Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Powder Paint</td>
<td>Inside outside</td>
<td>01</td>
<td>20 Micron</td>
</tr>
<tr>
<td></td>
<td>(2) Thermo setting powder</td>
<td></td>
<td>01</td>
<td>60 Micron</td>
</tr>
<tr>
<td>2.</td>
<td>Liquid paint</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Zinc Chromate(Primer)</td>
<td>Out side</td>
<td>02</td>
<td>45 micron</td>
</tr>
<tr>
<td></td>
<td>b) Synthetic Enamel(Finish Coat)</td>
<td>Out side</td>
<td>02</td>
<td>35 micron</td>
</tr>
<tr>
<td></td>
<td>c) Hot Oil paint</td>
<td>Inside</td>
<td>01</td>
<td>35 micron</td>
</tr>
</tbody>
</table>

7. DETAILED DESCRIPTION

7.1. Tank
7.1.1. the transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the shall be of welded construction.

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

7.1.3. All brams, flanges, lifting lugs, braces and permanent parts attached to the tank shall be welded and where practicable, they shall be double welded.

7.1.4. The main tank body of the transformer, excluding tap changing compartments and radiators. Shall be capable of withstand pressure of 760mm. of Hg.

7.1.5. 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.

7.1.6. 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, steps shall be provided to prevent over-compression.

7.1.7. 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.

7.2. **Tank Cover**

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 suitable sloped so that it dose not retain water.

7.3. **UNDER CARRIAGE**

7.3.1. The transformer tank shall be supported on steel structure with detachable plain rollers completely filled with oil. Suitable channels for movement of roller with transformer shall be space 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.

7.4. **CORE**

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

7.4.2. Each lamination shall be insulated such that it will not deteriorate due to mechanical pressure and the action of hot transformer oil.

7.4.3. The core shall be constructed either form high grade, non-aging Cold Rolled Grain Oriented (CRGO) silicon steel laminations conforming to grade M4 or better like HIB or laser grade. The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall not be more than 1.6 Tesla. The Bidder shall provide saturation curve of the core material, proposed to be used.
7.4.4. 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:

   a) Invoice of the supplier
   b) Mills test certificate
   c) Packing list
   d) Bill of lading
   e) Bill of entry certificate to customs

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

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

7.4.6. The insulation structure for the core to clap plates, shall be such as to withstand 2000 V DC voltage for one minute.

7.4.7. The complete core and coil shall be so assembled that the axis and the plane of the outer surface of the core assemble shall not deviate from the vertical plane by more than 25mm.

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

7.4.9. The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.

7.4.10. The core clamping structure shall be designed to minimize eddy current loss.

7.4.11. The framework and clamping arrangements shall be securely earthed.

7.4.12. The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength.

7.4.13. Oil ducts shall be provided, where necessary, to ensure adequate cooling inside the core. The welding structure and major insulation shall not obstruct the free flow of oil through such ducts.

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

7.4.15. The construction is to be of boltless core type. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The core and coil assemble shall be so fixed in the tank that shifting will not occur during transport or short circuits.

7.5. INTERNAL EARTHING

7.5.1. All internal metal parts of the transformer, with the exception of individual laminations and their individual clamping plates shall be earthed.

7.5.2. The top clamping structure shall be connected to the tank by a copper strap. The bottom clamping structure shall be earthed by one or more the following method.
7.5.3. 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.

7.5.4. Coil clamping rings of metal at earth potential shall be connected to the adjacent core clamping structure on the same side as the main earth connections.

7.6. WINDING

7.6.1. Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.

7.6.2. All low voltage windings for use in the circular coil concentric shall be wound on a performed insulating cylinder for mechanical protection of the winding in handling and placing around the core.

7.6.3. Winding shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness.

7.6.4. 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 the otherwise affected under the operating conditions.

7.6.5. Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive be used which will seal the coil and prevent evacuation of air and moisture and impregnation by oil.

7.6.6. Winding and connections shall be braced to withstand shocks during transport or short circuit.

7.6.7. Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil steel bolts, if used, shall be suitably treated.

7.6.8. Terminal of all winding shall be brought out of tank through bushings for external connections.

7.6.8.1. The completed core and coil assemble 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. Vacuum may be applied in either vacuum over or in the transformer tank.

7.6.8.2. 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 coil shall have high dielectric strength.

7.6.8.3. 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.

7.6.8.4. Adequate barriers shall be provided between coils and core 7 between high and low voltage coil. End turn shall have additional protection against abnormal line disturbances.
7.6.8.5. The insulation of winding shall be designed to withstand voltage stress arising from surge in transmission lines due to atmospheric or transient conditions caused by switching etc.

7.6.8.6. Tapping shall not be brought out from inside the coil or from intermediate turns and shall be so arranged as to preserve as far as possible magnetic balance of transformer at all voltage ratios.

7.6.8.7. Magnitude of impulse surges transferred from HV to LV windings by electro magnetic induction and capacitance coupling shall be limited to BILL of LV winding.

7.7. INSULATING OIL

7.7.1. The insulating oil for the transformer shall be of EHV grade, generally conforming to IS:335. No inhibitors shall be used in the oil.

7.7.2. The quantity of oil required for the first filling of the transformer and full specification shall be stated in the bid. The bidder shall quote the price of transformer complete with first filling of oil plus 10% extra. However, the rate of transformer oil in Rupees per litre shall be quoted separately also. The transformer oil shall be supplied in non-returnable drums.

7.7.3. 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.

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

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Characteristic</th>
<th>Requirement</th>
<th>Method of Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Appearance</td>
<td>The oil shall be clear and transparent and free from suspended matter or sediment.</td>
<td>A representative sample of oil shall be examined in a 100 mm thick layer at ambient temp.</td>
</tr>
<tr>
<td>02</td>
<td>Density at 20°C</td>
<td>0.89 g/cm³ Max.</td>
<td>IS:1448</td>
</tr>
<tr>
<td>03</td>
<td>Kinematic Viscosity at 27°C Max</td>
<td>27CST</td>
<td>IS:1448</td>
</tr>
<tr>
<td>04</td>
<td>Interfacial tension at 27°C Min.</td>
<td>0.03 N/m.</td>
<td>IS:6104</td>
</tr>
<tr>
<td>05</td>
<td>Flash point</td>
<td>136°C</td>
<td>IS:1448</td>
</tr>
<tr>
<td>06</td>
<td>Pour point max</td>
<td>-6°C</td>
<td>IS:1448</td>
</tr>
<tr>
<td>07</td>
<td>Neutralization Value (Total Acidity) Max.</td>
<td>0.03mg KOH/gm.</td>
<td>IS:335</td>
</tr>
<tr>
<td>08</td>
<td>Electric strength Breakdown (voltage) Min.</td>
<td>72.5 KV</td>
<td>IS:6792</td>
</tr>
<tr>
<td>09</td>
<td>Dielectric dissipation factor tan delta at 90°C</td>
<td>0.03 Max</td>
<td>IS:6262</td>
</tr>
<tr>
<td>10</td>
<td>Min specific resistance(resistivity) at 90°C</td>
<td>35X10 ohm cm (min)</td>
<td>IS:6103</td>
</tr>
<tr>
<td>11</td>
<td>Oxidation stability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Neutralization value after oxidation</td>
<td>0.40mg KOH/g</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Total sludge after oxidation</td>
<td>0.10% by weight max.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Presence of oxidation Inhibitor</td>
<td>The oil shall not contain anti oxidant Additives.</td>
<td>IS:335</td>
</tr>
<tr>
<td>15</td>
<td>Water content Max:</td>
<td>Less than 25ppm.</td>
<td>IS:2362</td>
</tr>
</tbody>
</table>
7.8. VALVES

i) Valves shall be of forged carbon steel up to 50mm. size and of gun mental or of cast iron bodies with gun metal fittings for sizes above 50mm. They shall be of full way type with screwed ends and 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.

ii) 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 screwed valves shall be furnished with pipe plugs for protection. Padlocks with duplicate keys shall be supplied along with the valves.

iii) 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.

iv) Each transformer shall be provided with following valves on the tank:

   a) drain valve so located as to completely drain the tank.
   b) Two filter valves on diagonally opposite corners of 50mm size.
   c) Oil sampling valves not less than 8mm at top and bottom of main tank.
   d) One 15mm. air release plug.
   e) Valves between radiators and tank.

Drain and filter valves shall be suitable for applying vacuum as specified in the specifications.

7.9. ACCESSORIES

7.9.1. Bushing

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.

iii) Bushing shall be designed and tested to comply with the applicable standards.

iv) Liquid oil filled bushings shall be equipped with liquid level indicators and means for sampling and draining the liquid. The angle of inclination to vertical shall not exceed 30degree.

v) Oil in oil-filled bushings shall meet the requirements of the transformer oil standards.

vi) Bushing rated for 400A and above shall have non-ferrous flanges 7 hardware.

vii) Fittings made of steel or malleable iron shall be galvanized.

viii) Bushing shall be so located on the transformers that full flashover strength will be utilized. Minimum clearances as required for the BIL shall be realized between live parts and live parts to earthed structures.

ix) All applicable routine and type tests certificates of the bushings shall be furnished for approval.
x) Bushing shall be supplied with bi-metalic terminal connector/ clamp/ washers suitable for fixing to bushing terminal and the PURCHASER’S specification conductors. The connector/clamp shall be rated to carry the bushing rated current without exceeding a temperature rise of 55°C over an ambient of 50°C. the connector/clamp shall be designed to be corona free at the maximum rated line to ground voltage.

xi) Bushing of identical voltage rating shall be interchangeable.

xii) The insulation class of high voltage neutral bushing shall be properly coordinated with the insulation class of the neutral of the low voltage winding.

xiii) Each bushing shall be so coordinated with the transformer insulation that all flashover will occur outside the tank.

7.9.2. Protection and Measuring Devices

i) Oil Conservator Tank

a) The Conservator tank 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.

b) The conservator tank shall be bolted into position so that it can be remove for cleaning purposes.

c) The conservator shall be fitted with magnetic oil level gauge with low level electrically insulated alarm contact.

d) Plain conservator fitted with silica gel breather.

ii) Pressure Relief Device.

The pressure relief device provided shall be 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. The device shall operate at a static pressure of less than the hydraulic test pressure of transformer tank. It shall be mounted direct on the tank. A pair of electrically insulated contract shall be provided for alarm and tripping.

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 located about 1200mm above ground level to facilitate sampling with the transformer in service. The device shall be provided with two electrically independent potential free contracts, 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 mercury contact type thermometer with 150mm dial for top oil temperature indication. The thermometer shall have adjustable, electrically independent potential free alarm and trip contacts. Maximum reading pointer and resetting device shall be
mounted in the local control panel. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Accuracy class of OTI shall be \( \pm 1\% \) or better. One No electrical contact capable of operating at 5 A AC at 230 volt supply.

b) **Winding temperature indicator (WTI)**

A device for measuring the hot spot temperature of the winding shall be provided. It shall comprise the following.

i) Temperature sensing element
ii) Image Coil.
iii) Mercury contacts
iv) Auxiliary CTS, If required to match the image coil, shall be furnished and mounted in the local control panel.

v) 150mm dial local indicating instrument with maximum reading pointer mounted in local panel and with adjustable electrically independent ungrounded contacts, besides that required for control of cooling equipment, one for high winding temperature alarm and one for trip.

vi) Calibration device.

vii) Two number electrical contact each capable of operating at 5 A ac at 230 Volt supply.

7.9.3. **Oil preservation Equipment**

7.9.3.1. **Oil Sealing**

The oil preservation shall be diaphragm type oil sealing in conservator to prevent oxidation and contamination of oil due to contact with atmospheric moisture.

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

i) Passage of air is through a dust filter and silica gel

ii) Silica gel is isolate 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 1400mm above rail top level.

7.10. **MARSHALLING BOX**

i) Sheet steel, weather, vermin and dust proof marshalling box fitted with required glands, locks, glass door, terminal Board, heater with switch, illumination lamp with switch, 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 slopping roof and the interior and exterior painting shall be accordance with the specification. Padlock along with duplicate key shall be supplied for marshalling box. The degree of protection shall be IP-55 or better.

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 equipments except c) shall be mounted on panels and back of panel wiring shall be used for inter connection. The temperature indicators shall be so mounted that the dials area not more than 1600 mm from the ground level and the door(s) of the compartment(s) shall be provided with glazed window of adequate size. The transformer shall be erected on a plinth which shall be 2.5 feet above ground level.

iii) To prevent internal condensation a metal clad heater with thermostat shall be provided. The heater shall be controlled by a MCB of suitable rating mounted in the box. The ventilation louvers suitably padded with felt shall also be provided. The louvers shall be provided with suitable felt pads to prevent ingress of dust.

iv) 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 compartment shall be sealed in suitable manner to prevent the ingress of moisture from the cable trench.

v) The control connection, wiring etc shall be as per clause 3.15 of this specification.

7.11 OFFLOAD TAPCHANGER.

i) The transformers shall be provided with off-load taps.

ii) The Transformer with off load tap changing gear shall have taps running from + 5% to – 10% in 6 equal steps of 2.5% each on HV winding for voltage variation

iii) The tap changing switch shall be located in a convenience position so that it can be operated from ground level. The switch handle shall be provided with locking arrangement along with top position indication thus enabling the switch to be locked in position.

iv) Suitable arrangement shall be provided to for local electrical & local manual operation. Provisions in the circuit shall be kept for gang operation of the tap changer with the tap changers of the transformers which may be added in parallel to this transformer in future.

v) An out of step device shall be provided for each transformer which shall be arranged to prevent further tap changing when transformer in a group operating in parallel control are operated out of step.

7.12 Fittings and Accessories:

The following fittings and accessories shall be provided on the transformers :

i) Conservator with isolating valves oil filling hole with cap and drain valve. The conservator vessel shall be filled with constant oil pressure diaphragm oil sealing system.

ii) Magnetic type oil level gauge (150 mm dia) with low oil level alarm contacts.

iii) Prismatic/toughened glass oil level gauge.

iv) Silica gel breather with oil seal and connecting pipe complete with first fill of activated silicagel or Alumina mounted at a level of 1300 mm above ground level.

v) A double float type Buchholz relay with isolating valve. Bleeding pipe and a testing cock the test cock shall be suitable for a flexible (pipe connection for checking its operation). A 5mm dia Copper pipe shall be connected from the lay test cock to a valve located at a suitable height above ground level to facilitate sampling of gas with the transformer in service. Interconnection between gas collection box and relay shall also be provided. The device shall be provided with
two electrically independent ungrounded contacts one for alarm on gas accumulation and the other for tripping on sudden oil surge. These contacts shall be wired up to transformer marshalling box. The relay shall be provided with shut of valve on the conservator side as well as on the tank side.

vi) Pressure relief devices (including pressure relief valve) and necessary air equalizer connection between this and the conservator with necessary alarm and trip contacts.

vii) Air release plugs in the top cover.

viii) Inspection cover access holes with bolted covers for access to inner ends of bushing etc.

ix) Winding temperature (n hot spot) indicating device for local mounting complete in all respects. Winding temperature indicator shall have three set of contacts to operate at different settings.

a) To provide winding temperature high alarm.
b) To provide temperature too high trip.

x) Dial thermometer with pocket for oil temperature indicator with one set of alarm and one set of trip contacts and maximum reading pointer.

xi) Lifting eyes or lugs for the top cover core and coils and for the complete transformer.

xii) Jacking pads.

xiii) Haulage lugs.

xiv) Protected type mercury/alcohol in glass thermometer and a pocket to house the same.

xv) Top and bottom filter valves on diagonally opposite ends with pad locking arrangement on both valves.

xvi) Top and bottom sampling valves.

xvii) Drain valve with pad locking arrangement.

xviii) Rating and connection diagram plate.

xix) Two numbers tank earthing terminals with associated nuts and bolts for connections to purchaser’s grounding strip.

xx) Bi-directional flagged rollers with locking and bolting device.

xxi) Marshalling Box (MB).

xxii) Shut off valve on both sides of flexible pipe connections between radiator bank and transformer tank.

xxiii) Cooling Accessories:

a) Requisite number of radiators provided with:
   - One shut off valve on top.
   - One shut off valve at bottom
   - Air release device on top
   - Drain and sampling device at bottom
   - Lifting lugs.

b) Air release device and oil drain plug on oil pipe connectors:

xxiv) Terminal marking plates for current transformer and main transformer.

a) Off load tap changer.

xxv) Oil preservation equipment.

xxvii) Oil temperature indicator.
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.

(ii) The contacts of various devices required or alarm and trip shall be potential free and shall be adequately rated for continuous making and breaking current duties as specified.

7.13 CONTROL CONNECTIONS AND INSTRUMENT AND WIRING TERMINAL BOARD AND FUSES:

i) Normally no fuses shall be used anywhere instead of fuses MCB’s (both in AC & DC circuits) shall be used. Only in cases where a MCB cannot replace a fuse due to system requirements a HRC fuse can be accepted.

ii) All wiring connections, terminal boards, fuses MCB’s and links shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation and the bare ends of stranded wire shall be seated together to prevent seepage of oil along the wire.

iii) Panel connections shall be neatly and squarely fixed to the panel. All instruments and panel wiring shall be run in PVC or non-rusting metal cleats of the compression type. All wiring to a panel shall be taken from suitable terminal boards.

iv) Where conduits are used, the runs shall be laid with suitable falls, and the lowest parts of the run shall be external to the boxes. All conduit runs shall be adequately drained and ventilated conduits shall not be run at or below ground level.

v) When 400 volt connections are taken through junction boxes or marshalling boxes, they shall be adequately screened and 400 volts Danger Notice must be affixed to the outer side of the junction boxes or marshalling box. Proper colour code for Red Yellow Blue wires shall be followed.

vi) All box wiring shall be in accordance with relevant ISS. All wiring shall be of stranded copper (48 strands) of 1100 volt grade and size not less than 2.5 sq.mm.

vii) All wires on panels and multi core cables shall have ferrules, for easy identifications, which bear the same number at both ends, as indicated in the relevant drawing.

viii) At those points of interconnection between the wiring carried out by separate contractors, where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment.

ix) The same ferrule number shall not be used on wires in different circuits on the same panels.

x) Ferrules shall be of white insulating material and shall be provided with glossy finish to prevent the adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by dampness or oil.

xi) Stranded wires shall be terminated with tinned Ross Courtney terminals, claw washers or crimped tubular lugs. Separate washers shall be suited to the size of the wire terminated. Wiring shall in general, be accommodated on the sides of the box and the wires for each circuit shall be separately grouped. Back of panel wiring shall be arranged so that access to the connecting items of relays and other apparatus is not impeded.

xii) 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.

xiii) Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of stranded (48 no.) copper wire of strip having a cross section of not less than 2 sq. mm where strip
is used, the joints shall be sweated. The copper wire shall have green colored insulation for earth connections.

xiv) All wiring diagram for control and relay panel shall preferably be drawn as viewed from the back and shall shown the terminal boards arranged as in services.

xv) Terminal block rows should be spaced adequately not less than 100 mm apart to permit convenient access to external cables and terminations.

xvi) Terminal blocks shall be placed with respect to the cable gland (at a minimum distance of 200mm) as to permit satisfactory arrangement of multi core cable tails.

xvii) Terminal blocks shall have pairs of terminals for incoming and outgoing wires. Insulating barriers shall be provided between adjacent connections. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals. The terminals shall be adequately protected with insulating dust proof covers. No live metal shall be exposed at the back of the terminal boards. CT terminals shall have shorting facilities. The terminals for CTs should have provision to insert banana plugs and with isolating links.

xviii) All interconnecting wiring as per the final approved scheme between accessories of transformer and marshalling box is included in the scope of this specification and shall be done by the Transformer supplier.

xix) The schematic diagram shall be drawn and fixed under a transparent pros pane sheet on the inner side of the marshalling box cover.

xx) To avoid condensation in the Marshalling Box a space heater shall be provided with an MCB and thermostat.

xxi) Suitable MV, CFL light shall be provided in the Marshalling Box for lightning purpose.

7.14 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 minimize interference with communication circuits. Transformer noise level when energized at normal voltage and frequency shall be as per NEMA stipulations.

8. INSPECTION AND TESTING;

(i) The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the transformer. An indicative in inspection is given under Clause No.4.1. This is however not intended to form a comprehensive programme as it is contractor’s responsibility to draw up and carry out such a programme duly approved by the purchaser.

(ii) The contractor shall carry out type tests and routine tests on the transformers.

(iii) Only one no of transformer of each rating will be subjected to type test. The charges for conducting each of type tests shall be included in the bid price and no separate type test charges shall be paid. The purchaser reserves the right to conduct any or all type tests at CPRI/National Govt. Approved Laboratory, if the type tests were not conducted earlier on transformers of the same rating and design.

(iv) The pre shipment checks shall also be carried out by the contractor.
The requirements on site tests are as listed in the specifications.

Certified test report and oscillograms shall be furnished to the purchaser consultants for evaluation as per the schedule of distribution of documents. The contractor shall also evaluate the test results and rectify the defects in the equipment based on his and the purchaser’s evaluations of the tests without any extra charges to the purchaser. Manufacturer’s test certificate in respect of all associated auxiliary and ancillary equipment shall be furnished.

The bidder shall state in his proposal the testing facilities available at his works. In case full testing facilities area not available the bidder shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity.

8.1 INSPECTION:

i) Tank and conservator.
   a) Inspection of major weld.
   b) Crack detection of major strength weld seams by dye penetration test.
   c) Check correct dimensions between wheels demonstrate turning of wheels through 90” and further dimensional check.
   d) Leakage test of the conservator.

ii) Core:
   a) Sample testing of core materials for checking specific loss properties magnetization characteristics and thickness.
   b) Check on the quality of varnish if used on the stampings.
   c) Check on the amount of burrs.
   d) Visual and dimensional check during assembly stage.
   e) Check on completed core for measurement of iron loss determination of maximum flux density.
   f) Visual and dimensional checks for straightness and roundness of core thickness of limbs and suitability of clamps.
   g) High voltage DC test (2KV for one minute) between core and clamps.

iii) Insulating material.
   a) Sample check for physical properties of materials.
   b) Check for dielectric strength.
   c) Check for the reaction of hot oil on insulating materials.

iv) Winding.
   a) Sample check on winding conductor for mechanical and conductivity.
   b) Visual and dimensional checks on conductor for scratches, dent mark etc.
   c) Sample check on insulating paper for PH value, electric strength.
   d) Check for the bonding of the insulating paper with conductor.
   e) Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.
   f) Check for absence of short circuit between parallel strands.

v) Checks before drying progress:
   a. Check condition of insulation on the conductor and between the windings.
   b. Check insulation distance between high voltage connections between high voltage connection cables and earth and other live parts.
   c. Check insulating distances between low voltage connections and earth and other parts.
d. Insulating test for core ear thing.

v) Check during drying process:
   b) Check for completeness of drying.

vii) Assembled Transformer:
   a. Check completed transformer against approved outline drawing, provision for all fittings finish level etc.
   b. Jacking test on the assembled Transformer.

viii) Oil:

   All standard test in accordance with IS: 335 shall be carried out on Transformer oil sample before filling in the transformer.

ix) Test report for bought out items:

   The contractor shall submit the test reports for all bought out / sub contracted items for approval.
   a) Buchholz relay.
   b) Sudden pressure rise relay on Main Tank.
   c) Winding temperature indicators (for TX capacity >10 MVA)
   d) Oil temperature indicators.
   e) Bushings
   f) Bushing current transformers in neutral (if provided)
   g) Marshalling box
   h) Off load tap changer
   i) Any other item required to complete the works.
   j) Porcelain, bushings, bushing current transformers, wherever provided, winding coolers, control devices, insulating oil and other associated equipment shall be tested by the contractor in accordance with relevant IS. If such requirement is purchased by the contractor on a sub contract he shall have them tested to comply with these requirements.

8.2 FACTORY TESTS:

   i) All standards routine tests in accordance IS.2026 with dielectric tests corresponding as per latest amendments to IS.2026 shall be carried out.
   ii) All auxiliary equipment shall be tested as per the relevant IS. Test certificates shall be submitted for bought out items.
   iii) High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

   iv) Following additional routine tests shall also be carried out on each transformer.

      a) Magnetic circuit test.
         Each core shall be tested for 1 minute at 2000 volt DC
      b) Oil leakage test on transformer.

8.2.1 Type test:

   The transformer shall be subjected to the following type tests particularly short circuit and impulse withstand tests at CPRI/National Govt. approved laboratory at the discretion of the purchaser if these
tests were not conducted on the transformers of the offered design and rating at the cost of the manufacturer.

1. Tan delta measurement and capacitance of each winding to earth (with all other windings earthed) and between all windings connected together to earth.
3. Temperature rise test.
5. Tank vacuum test
6. Tank pressure test.
7. Lightning impulse withstand test for line and neutral terminal.

The above type tests will be conducted by the supplier at their own cost if the design/test result of the type tested transformer differs from those of the offered transformer as per their bid.

8.2.2. STAGE INSPECTION

The supplier shall offer the core, windings & tank of each transformer for inspection by the purchaser’s representative(s). During stage Inspection, all the measurements like diameter, window height, leg centre, stack width, stack thickness, thickness of laminations etc. for core assembly, conductor size, Insulation thickness, I.D., O.D., winding height, major & minor insulations for both H.V. & L.V. windings, length, breadth, height & thickness of plates of Transformer tank, the quality of fittings & accessories will be taken / determined. The supplier can offer for final inspection of the transformers subject to clearance of the stage Inspection report by the purchaser.

8.2.3. Routine Tests

Transformer routine tests shall include tests stated in latest issue of IS: 2026 (Part – 1). These tests shall also include but shall not be limited to the following:

(i) Measurement of winding DC resistance.
(ii) Voltage ratio on each tapping & check of voltage vector relationship.
(iii) Impedance voltage at all tapings.
(iv) Magnetic circuit test as per relevant ISS or CBIP manual or latest standard being followed.
(v) Load losses at normal tap & extreme taps.
(vi) No load losses & no load current at rated voltage & rated frequency, also at 10% to 121% of rated voltage in steps.
(vii) Absorption index i.e. insulation resistance for 15 seconds & 60 seconds (r 60/ r 15) & polarization index i.e. Insulation Resistance for 10 minutes & one minute (R 10 mt /R 1mt).
(viii) Induced over voltage withstand test.
(ix) Separate source voltage withstand test.
(x) Ten delta measurement & capacitance of each winding to earth (with all other windings earthed) & between all windings connected together to earth.
(xi) Measurement of zero sequence impedance

Auxiliary circuit tests

Oil BDV tests

Measurement of neutral unbalance current which shall not exceed 2% of the full rated current of the transformer.

Magnetic balance test

Leakage test.

Six (6) set of certified test reports & oscillographs shall be submitted for evaluation prior to dispatch of the equipment. The contractor shall also evaluate the test result & shall correct any defect indicated by his & Purchaser’s evaluation of the tests without charge to the Purchaser.

8.4. TANK TESTS

(a) Oil leakage test:
The tank & oil filled compartments shall be tested for oil tightness completely filled with air or oil of viscosity not greater than that of insulating oil conforming to IS : 335 at the ambient temperature & applying a pressure equal to the normal pressure plus 35 KN/ m² measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours of oil & one hour for air & during that time no leak shall occur.

(b) Pressure test
Where required by the purchase, one transformer tank of each size together with its radiator, conservator vessel & other fittings 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 & maintained for one hour.

© Vacuum Test
One transformer tank of each size shall be subjected to the vacuum pressure of 60 mm of mercury. The tanks designed for full vacuum shall be tested at an internal pressure of 3.33 KN/ m² (25 mm of mercury) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in C.B.I.P. manual on Transformer (Revised 1999) without affecting the performance of the transformer.

8.5. PRE-SHIPMENT CHECK AT MANUFACTURERS WORKS

i) Check for proper packing & preservation of accessories like radiators, bushings, explosions vent, dehydrating breather, rollers, buchholz relay, control cubicle connecting pipes & conservator etc.

ii) Check for proper provision of bracing to arrest the movement of core & winding assembly inside the tank.

iii) Gas tightness test to conform tightness.

8.6. INSPECTION AND TESTING AT SITE
The Engineer authorized from CESU along with the contractor’s site engineer shall carry out detailed inspection covering areas right from the receipt of material up to commissioning stage. An indicative program of inspection as envisaged by the Engineer is given below.

8.6.1. receipt & Storage Checks

i) Check & record conditions of each package visible parts of the transformers etc. for any damage.

ii) Check & record the gas pressure in the transformer tank as well as in the gas cylinder.

iii) Visual check of core & coils before filling up with oil & also check condition of core & winding in general.

8.6.2. Installation Checks

i) Inspection & performance testing of accessories like tap changer etc.

ii) Check choking of the tubes of radiators

iii) Test on oil samples taken from main tank top & cooling system. Samples should be taken only after the oil has been allowed to settle for 24 hours.

iv) Check the whole assembly for tightness, general appearance etc.

v) Oil leakage tests.

8.6.3. Pre-Commissioning Tests

After the transformer is installed, the following pre-commissioning tests & checks shall be done before putting the transformer in service.

i) Dry out test

ii) Megger test

iii) DC Resistance measurement of windings

iv) Ratio test on all taps

v) Phase relationship test (Vector grouping test)

vi) Buchholz relay alarm & surge operation test

vii) Low oil level (in conservation) alarm

viii) Temperature Indicators

ix) Marshalling kiosk
8.6.4. **The following additional checks shall be made:**

i) All oil valves are incorrect position closed or opened as required

ii) All air pocket are cleared

iii) Thermometer pocket are filled with oil

iv) Oil is at correct level in the bushing, conservator, diverter switch & tank etc.

v) Earthing connections are made.

vi) Colour of Silica gel is blue

vii) Bushing arcing horn is set correctly & gap distance is recorded.

viii) CT polarity & ratio is correct.

8.7. **PERFORMANCE**

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

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

ii) Radio interference & Noise level

iii) The transformer shall be designed with particular attention to the suppression of third & fifth harmonics so as to minimize interference with communication circuits.

8.8. **FAULT CONDITIONS**

a) The transformer shall be capable of withstanding for two(2) seconds without damages any external short circuit to earth

b) Transformer shall be capable of withstanding thermal & mechanical stresses conveyed by symmetrical or asymmetrical faults on any winding. This shall be demonstrated through calculation as per IS : 2026.

c) Transformer shall accept, without injurious heating, combined voltage & frequency fluctuation which produce the 125% over fluxing condition for one minute.

Certified test report & oscillograms shall be furnished to the Purchaser / Consultant for evaluation as per the schedule of distribution of documents. The Contractor shall also evaluate the test results & rectify the defects in the equipment based on his & the Purchaser’s evaluations of the tests.
without any extra charges to the Purchaser. Manufacturer’s test Certificates in respect of all associated auxiliary & ancillary equipment shall be furnished.

The bidder shall state in his proposal the testing facilities available at his works. In case full testing facilities are not available, the bidder shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity testing.

8.9. WITNESSING OF TESTS AND EXCESSIVE LOSSES

i) The purchaser & or his representative reserve the right to witness any or all test or to accord waival at its soil discretion.

ii) The Purchaser reserves the right to reject the transformer if losses exceed the maximum specified as per Clause No 2. SPECIFIC TECHNICAL REQUIREMENTS (STANDARD CONDITIONS), item-37 & 38 of this specification or if temperature rise of oil & winding exceed the values specified at item-26 of the above clause.

9. CAPITALISATION OF LOSSES AND LIQUIDATED DAMAGES FOR EXCESSIVE LOSSES

9.1. LOSSES:

Transformer with lower losses shall be preferred. The bidder shall indicate the values of load and no load losses of the transformer in his bid.

9.2. CAPITALISATION OF LOSSES

For total cost evaluation, the capitalized cost of losses will be taken into account as specified in S.C.C. of this bid document.

However, Liquidated damages for non-performance for transformers shall be recovered from the contractor in case he is unable to achieve the quoted guaranteed figures at the rate equivalent to the double of the rate considered for loss evaluation or else the transformer(s) will be rejected outrightly.

10. SPARE PARTS

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

10.1. Mandatory spare Parts

The suppliers shall provide the following mandatory spares for each of Transformer supplied.

1. H.V. & L.V. bushing – 1No.
2. Bimetallic connector – 1 complete set.

10.2. 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 & shall contain all the drawings & information required for erection, operation & maintenance of the transformer.

The manuals shall include amongst other, the following particular:
Technical Specification for 33/11kV Power Transformers (APDRP Scheme)

a) Marked erection prints identifying the components, parts of the transformer as dispatched with assembly drawings.

b) Detailed dimensions, assembly & description of all auxiliaries.

c) Detailed views of the core & winding assembly, winding connections & tapings tap changer construction etc. These drawings are required for carrying out overhauling operation at site.

d) Salient technical particulars of the transformer.

e) Copies of all final approved drawings.

f) Detailed O&M instructions with periodical check lists & Performa etc.

10.3. COMPLETENESS OF EQUIPMENT

All fitting & accessories, which may not be specifically mentioned in the specification but which are necessary for the satisfactory operation of the transformer, shall be deemed to be included in the specification & shall be furnished by the supplier 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.

TOOLS AND TACKLES

All the necessary tools & tackles required for normal operation & maintenance of the transformers shall be supplied by the Contractor.

COMMISSIONING

The equipment shall be commissioned as per CBIP manual, IS: 10028 & manufacturer’s recommendations. All the related drawings & manuals shall be pre-requisite for release of final payment.

NON COMPLIANCE SCHEDULE

On this schedule the bidder shall provide a list of non compliance with this specification, documenting the effects that such non compliance is likely to have on the equipment’s life & operating characteristics. Each Non Compliance shall refer to the relevant clause of the specification.

Where there are no deviations from specification, the bidder shall so indicate by stating “No deviations” in this schedule.

TEST CERTIFICATES SCHEDULE

On this schedule a list of the test certificates included with the bid shall be provided. The list should include type test certificates & sample routine test reports. Each certificate listed shall be referred to the relevant specification clause & item of equipment to which the test applies.