**BIDDING DOCUMENT**
**FOR**

# "Augmentation of 2x100 MVA, 220/132 KV Rangia GSS By 2x200 MVA Auto-Transformer (Phase-II)"

# ASSAM ELECTRICITY GRID CORPORATION LIMITED

**Volume-II**

**Bid Identification No:**
**AEGCL/MD/TECH-1218/2025-26/BID**

# Section 3- Purchaser's Requirements

This Section contains the Specification, the Drawings, and supplementary information that describe the Works to be procured.

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# Section 3
# Purchaser's Requirements

**3.0. Scope of Works**

The brief description of scope of Works covered under this Bidding Document is furnished below:

i. The work involves design, engineering, manufacture, assembly, inspection, testing at manufacturer's works before dispatch, packing, supply, including insurance during transit, delivery at site, subsequent storage, civil work, erection, commissioning and related works at site of various equipment and materials including power transformers as specified in BoQ and subsequent Clauses and Sections.

ii. It is not the intent to specify completely herein all details of design and construction of the equipment and accessories. However, the equipment and accessories shall conform in all respects to high standards of engineering, design and workmanship and be capable of performing in continuous operation up to the bidder's guarantees in a manner acceptable to the Employer. The Employer will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material, which in his judgment is not in full accordance therewith.

iii. Whether called for specifically or not, all accessories and work required for the completion of the work are deemed to be considered as a part of the Bidder's scope, unless and until mentioned very clearly as excluded.

**3.1. Bill of Materials**

3.1.1. *The Bill of Quantities is furnished in Schedule Nos. 1, 2, 2A of Section – 2.*

3.1.2. *The items mentioned in these Schedules shall only be used while quoting the bid prices. If any item which is not specifically mentioned in these Schedules but required to complete the works as per Specification shall deemed to be included in any of the items of these schedules. No modifications/ additions/ deletions shall be made by the bidder to the items and quantities given in these schedules.*

**3.2. Contractor to Inform Himself Fully**

3.2.1. The contractor should ensure that he has examined the Specifications and Schedules as brought out in this Section as well as other Sections of The Bidding document and has satisfied himself as to all the conditions and circumstances affecting the contract price and fixed his price according to his own views on these matters and acknowledge that no additional allowances except as otherwise provided therein will be levied.

3.2.2. The Purchaser shall not be responsible for any misunderstanding or incorrect information obtained by the contractor other than information given to the contractor in writing by the Purchaser.

**3.3. Service Conditions**

3.3.1. The plant and materials supplied shall be suitable for operation under the following climatic and other conditions:

a) Peak ambient day temperature in still air: 45°C
b) Minimum night temperatures: 0°C
c) Reference ambient day temperature: 45°C
d) Relative Humidity a) Maximum: 100 %
b) Minimum: 10 %
e) Altitude: Below1000 M above MSL
f) Maximum wind pressure: As per IS: 802 latest code
g) Seismic Intensity: ZONE-V as per IS 1893.

**3.4. Conformity with Indian Electricity Rules & Other Local Regulations**

3.4.1. The Contractor shall note that all substation works shall comply with the latest provisions of Indian Electricity Rules and with any other regulations. Local authorities concerned in the administration of the rules and regulation relating to such works shall be consulted, if necessary, about the rules and regulations that may be applicable.

**3.5 STANDARDS**

3.5.1 The equipment covered by this specification shall, unless otherwise stated be designed, constructed and tested in accordance with the latest revisions of relevant Indian Standards and shall conform to the regulations of local statutory authorities.

3.5.2 In case of any conflict between the standards and this specification, this specification shall govern.

3.5.2.1 Equipment conforming to other international or authoritative Standards which ensure equivalent or better performance than that specified under Clause 3.5.1 above shall also be accepted. In that case relevant extracts of the same shall be forwarded with the bid.

**3.6. Contractor's Requirement**

3.6.1. The Contractor should be in possession of a valid E.H.V. Electrical Contractor Licence and Electrical Supervisory Licence issued by the Chief Electrical Inspector, Govt. of Assam, as per the provision of Law. An attested copy of the aforementioned Licence must be handed over to the Owner for his record prior to handing/ taking over of sites.

3.6.2. All the works shall also be inspected by the Chief Electrical Inspector, Govt. of Assam or his authorised representatives. It is the responsibility of the Contractor to obtain pre-requisite commissioning clearance of any equipment from the said Inspectorate. The Contractor will pay necessary fees to the Inspectorate, which it may levy.

## GENERAL TECHNICAL REQUIRMENT (GTR)

**3.7.1.1 GENERAL**

The following provisions shall supplement all the detailed technical specifications and requirements brought out in accompanying Technical Specifications. The Contractor's proposal shall be based upon the use of equipment and materials complying fully with the requirements specified herein. It is recognized that the Contractor may have standardized on the use of certain components, materials, processes or procedures different to those specified herein. Alternate proposals offering similar equipment based on the manufacturers standard practice will also be considered, provided such proposals meet the specified design standard and performance requirement and are acceptable to AEGCL.

**3.7.1.2 SYSTEM PARAMETERS**

| S. No. | Description of Parameters | 400KV System | 220KV System | 132KV System | 33 KV System |
|---|---|---|---|---|---|
| 1. | System Operating Voltage | 400 KV | 220 KV | 132 KV | 33 KV |
| 2. | Maximum operating voltage of the system (rms) | 420 KV | 245 KV | 145 KV | 36 KV |
| 3. | Rated Frequency | 50 Hz | 50 Hz | 50 Hz | 50 Hz |
| 4. | No. of phase | 3 | 3 | 3 | 3 |
| 5. | Rated Insulation levels | | | | |
| i | Full wave impulse withstand voltage (1.2/50 Microsecs.) | 1425 kVP | 1050kVP | 650 kVP | 250 kVP / 170 kVP |
| ii | Switching impulse withstand voltage (250/ 2500 micro sec.) dry and wet | 1050kVP | - | - | - |
| iii | One-minute power frequency dry / wet withstand voltage (rms) | 650 KV / 520 KV | 460 KV | 275 KV | 95KV/ 70KV |
| 6 | Corona extinction voltage | 320 KV | 156 KV | 105 KV | - |

| | | | | | |
|---|---|---|---|---|---|
| 7 | Max. radio interference voltage for frequency between 0.5MHz & 2 MHz at 508 kV rms for 765kV, 320 kV rms for 400 KV system, 156 KV rms for 220 KV system & 92 KV rms for132 KV system | 1000 microvolt | 1000 microvolt | 500 microvolt | |
| 8 | Minimum creepage distance @ 31 mm/KV | 13020 mm | 7595 mm | 4495 mm | 1116 mm |
| 9 | Min. Clearances | | | | |
| i | Phase to spacing for installation | 7000 mm | 4500 mm | 3000 mm | 1500 mm |
| ii | Ground clearances from lowest live terminal of equipment from ground level | 8200 mm | 7000 mm | 5000 mm | 4000 mm |
| 10 | Rated short circuit current /for three sec. duration | 63 KA for three seconds | 50 KA for three seconds | 40 KA for three seconds | 31.5 KA for three seconds |
| 11 | System Neutral earthing | Effectively Earthed | Effectively Earthed | Effectively Earthed | Effectively Earthed |

**3.7.2DESIGN AND STANDARDISATION**

The Works covered by the specification shall be designed, manufactured, built, tested and commissioned in accordance with the Act, Rules, Laws and Regulations of India. The Equipment(s) shall also conform to the requirements detailed in the referred standards, which shall form an integral part of the Specification, in addition to meeting the specific requirements called for elsewhere in the Specification. The Contract works shall be designed to facilitate inspection, cleaning and repairs, and for operation where continuity of supply is the first consideration. Apparatus shall be designed to ensure satisfactory operation in all atmospheric conditions prevailing at the Site(s) and during such sudden variation of load and voltage as may be met with under working conditions on the system, including those due to faulty synchronizing and short circuit.

The design shall incorporate all reasonable precautions and provisions for the safety of those concerned in the operation and maintenance of the Contract Works and of associated works supplied under other contracts.

Where the Specification does not contain characteristics with reference to workmanship, equipment, materials and components of the covered equipment, it is understood that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.

In case where the equipment, materials or components are indicated in the specification as 'similar' to any special standard, AEGCL shall decide upon the question of similarity. When required by the Specification; or when required by AEGCL the Contractor shall submit, for approval, all the information concerning materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Contractor.

The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expense. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements and shall be used throughout the design. All

joints and fastenings shall be so devised, constructed and documented that the component parts shall be accurately positioned and restrained to fulfil their required function.
All outdoor apparatus and fittings shall be designed so that water cannot collect at any point. Grease lubricators shall be fitted with nipples and where necessary for accessibility, the nipples shall be placed at the end of extension piping.
All water and oil pipe flanges shall be to IS 6392/BS 4504 or other equivalent standard, as regards both dimensions and drilling, unless otherwise approved.
Cast iron shall not be used for chambers of oil filled apparatus or for any part of the equipment which is in tension or subject to impact stresses.
Kiosks, cubicles and similar enclosed compartments shall be adequately ventilated to restrict condensation. All contractor or relay coils and other parts shall be suitably protected against corrosion.
All apparatus shall be designed to obviate the risk of accidental short circuit due to animals, birds, insects, mites, rodents or micro-organisms.
Corresponding parts shall be interchangeable. Where required by AEGCL the Contractor shall demonstrate this quality.

**3.7.3QUALITY ASSURANCE**

**3.7.3.1 General**

To ensure that the supply and services under the scope of this Contract, whether manufactured or performed within the Contractor's works or at his Sub-Contractor's premises or at Site or at any other place of work are in accordance with the Specification, with the Regulations and with relevant Indian or otherwise Authorized Standards the Contractor 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 Contractor will use to ensure that the Works comply with the Contract requirements shall be defined in the Contractor's Quality Plan for the Works.
The Contractor 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."
AEGCL written approval is required to authorize 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 AEGCL does not attend after receiving documented notification in accordance with the agreed procedures and with the correct period of notice, then work may proceed.

**3.7.3.2 Quality assurance programme**

Unless the Contractor's Quality Assurance System has been audited and approved by AEGCL, a Quality Assurance Program for the Works shall be submitted to AEGCL for approval a minimum of one month prior to commencement of the works, or such other period as shall be agreed upon by AEGCL. The Quality Assurance Program 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 Contractor's 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 the control of documentation
- The system for the retention of records
- The arrangements for the Contractor's internal auditing
- A list of the administration and work procedures required to achieve and verify the Contract's Quality requirements. These procedures shall be made readily available to AEGCL for inspection on request.

**3.7.3.3 Quality plans**

The Contractor shall draw up for each section of the work Quality Plans which shall be submitted to AEGCL for approval at least two weeks prior to commencement of 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 program sequence
- The structure of the Contractor's organisation for the Contract
- The duties and responsibilities assigned to staff ensuring quality of work for Contract
- Hold and Notification points
- Submission of engineering documents required by the Specification
- The inspection of materials and components on receipt
- Reference to the Contractor's work procedures appropriate to each activity
- Inspection during fabrication/construction
- Final inspection and test

**3.7.3.4 Inspection and testing**

The prime responsibility for inspection and testing rests with the Contractor. The inspection or its waiver by AEGCL does not relieve the Contractor of any obligations or responsibilities to carry out the work in accordance with the Contract.

The inspection and testing shall be documented such that it is possible to verify that it was performed. Records of inspection shall include as a minimum the contract identity, operation/inspection, technique used, acceptance standard, acceptability, identity of inspector/tester and date of inspection/test.

**3.7.3.5 Non-conforming product**

The Contractor shall retain responsibility for the disposition of non-conforming items.

**3.7.3.6 Monitoring of quality arrangements**

During the course of the Contract AEGCL may monitor the implementation of the Quality Assurance arrangements. Monitoring will be by surveillance of the activities at work locations and/or by formal audits of the adherence of the Contractor to the systems and procedures which constitute his Quality Assurance arrangements. Corrective actions shall be agreed and implemented in respect of any deficiencies.

The Contractor shall provide any facilities, including access, which may be required by AEGCL for monitoring activities.

AEGCL may participate on an agreed basis in the Contractor's monitoring of a sub- contractor's Quality Assurance arrangements.

**3.7.3.7 Method statement**

Prior to commencing work, the Contractor shall submit a method statement setting out full details of his method of working. This is a Hold Point.

Details of the Contractor's method of working shall also be submitted at the time of Bidding.

**3.7.4 HEALTH, SAFETY AND ENVIRONMENT (HSE) PLAN**

**3.7.4.1 General**

**The contractor/subcontractor should adhere to the Environmental and Social Management Plan (ESMP). The payment is linked towards compliance to responsibility specified under the generic ESMP attached in Chapter-38 of Vol-II. The overall responsibility for compliance of ESMP will stand with the Project Manager with support of Health and safety Specialist. The contractor is abided to comply with the project specific ESMP which can be issued by AEGCL to contractor during the complete tenure of project.**

Within one month of award of contract the Contractor shall produce a HSE Plan for the contract and submit for the approval of AEGCL. The HSE Plan is described in the following sections. The same is to submit to CGM (PP&D) and ESIA Consultant for approval.

The primary objective of the HSE Plan is for the contractor to demonstrate that he has the capability to carry out the contract work in a cost-effective manner, giving due consideration to the Health, Safety and Environmental and Social management of both his own employees, those of the Employer and anyone who may be affected by his activities and in full compliance with the ESMP.

Special arrangements shall be made to accommodate for gender-inclusive engagements and participation of vulnerable people, to ensure the implementation of the social development and gender relevant features included in the design of the project, including monitoring of occupational and community health and safety,

community awareness activities, compliance of core labour standards, prevention of Gender-based violence (GBV) and Sexual exploitation (SE) risks.

**3.7.4.2 Content of HSE Plan**

The general structure of the HSE Plan is outlined in 7.4.3. The HSE Plan will comprise two parts i.e.:

Part: I: Sections 1 to 5, covering general HSE management and controls. The following would be attached as appendices, where appropriate:

- Organisation chart showing the proposed Contractors HSE organisational structure
- The CV"s, duties and responsibilities of the following personnel:
  - (i) Contract Manager
  - (ii) Contractors Site Representatives
  - (iii) Environment, Social, Health and Safety Officer
  - (iv) Site Environment, Social, Health and Safety Officers

Part: II: Section 6, providing a summary of hazards and controls.

**3.7.4.3 General structure of HSE Plan**

The HSE Plan shall conform to the following general structure:

1. Contractors Policy Statement
2. Health
   - 2.1 First Aid
   - 2.2 Primary health care
   - 2.3 Occupational and community health
3. Safety
   - 3.1 Objectives and targets
   - 3.2 Organisation and responsibilities
   - 3.3 HSE meetings
   - 3.4 Motivation, communication and community awareness.
   - 3.5 HSE training
   - 3.6 Audits and inspections
   - 3.7 Emergency response
   - 3.8 Safety function
   - 3.9 Accident investigating and reporting
   - 3.10 Standards
   - 3.11 Personal protective equipment
4. Environment
   - 4.1 Waste management
   - 4.2 Chemicals management
   - 4.3 Environmental impacts on Air, Noise, and Waterbody
   - 4.4 Fuels and Hazardous Substances Management
   - 4.5 Water Resources Management
   - 4.6 Drainage Management
   - 4.7 Soil Quality Management
   - 4.8 Topography and Landscaping
   - 4.9 Borrow Areas Management
   - 4.10 Protection of Flora and Fauna
   - 4.11 Protection of Fisheries
   - 4.12 Construction Camp Management, including GBV and SE risk prevention measures
   - 4.13 Cultural, Religious Issues, Chance find procedures
   - 4.14 Critical areas
   - 4.15 Subcontractors
   - 4.16 Summary of hazards and controls

**3.7.4.4 Section 6 of HSE Plan**

In addition to general hazards and their controls, the following hazards have been identified as specific to this contract and therefore the contractor should demonstrate that he is capable of providing the necessary controls for the work:

- Working within a Permit to Work system
- Working adjacent to live high voltage equipment
- Working adjacent to, and in the vicinity of, live high voltage overhead lines
- Working at elevation
- Lifting operations
- Use of explosives
- Use of heavy machinery including cranage, pile rigs and concrete mixers
- Excavation works
- Work in confined spaces
- Working with insulating oil
- Working with compressed gas
- Rotating machinery

The Contractor should demonstrate his understanding of these hazards by either proposing specific controls for each of them or by giving supporting documentation which demonstrates that such controls already exist.

**3.7.5. PROGRESS REPORTING**

The Contractor shall submit for approval, within four weeks of the issue of letter of award, an outline of the design, engineering, material procurement, production, site mobilisation, man and machine deployment, delivery, erection, testing, commissioning, and handing over Programme as mentioned earlier. Within a further period of 4 weeks the Contractor shall provide a detailed programme scheduling the future activities in the form of Bar chart and/or any other form to be agreed upon by AEGCL. The Contractor shall submit monthly progress reports to AEGCL office not later than the fifth day of the following month. The reports shall show clearly and accurately the position of all activities associated with design, material procurement, manufacture, works tests, shipping, site erection, testing and commissioning with regard to the agreed contract programme. In addition to the routine monthly progress report the Contractor shall also submit to AEGCL by the 25th day of every month, a man hour schedule for the following month, detailing the man hours scheduled for that month, skill-wise and area-wise. The preferred format for presentation of programme is MS Project version 4.0 or any latest. The programme and monthly updates shall be submitted on Email/CD/Hard copy. The design aspect of the progress report shall include a comprehensive statement on drawing and calculations submitted for approval. The position on material procurement shall give the date and details of orders placed and indicate the delivery date quoted by the manufacturer. If any delivery date has an adverse effect on the contract programme the Contractor shall state the remedial action taken to ensure that delays do not occur. The position on manufacture shall indicate the arrival of material, the progress of manufacture and date at which the equipment will be ready for transport. Any events that may adversely affect completion in the manufacturer's works shall also be reported. All works, tests executed shall be listed and the test-results shall be remarked upon. Any test failures shall be highlighted, and the Contractor shall detail the necessary steps taken in order to avoid any adverse effect on the contract completion dates. 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.

The site works shall be segregated into civil, mechanical and electrical works for reporting purposes and each section of the site works shall be monitored giving the percentage completion and the estimated completion date in accordance with the contract programme. The number of men working on site, both labour and supervisory staff, shall be reported together with any incidents or events that may affect the progress of site works.

Any delays which may affect any milestone or final completion dates shall be detailed by the Contractor who shall state the action taken to effect contract completion in accordance with the contract programme.

The contractor shall provide two copies of the progress report to AEGCL office. All other activities listed in other sections of bid document also shall be provided.

**3.7.6. STANDARDS**

Except where otherwise specified or implied, the Contract Works shall comply with the latest edition of the relevant Indian Standards, International Electro technical Commission (IEC) standards and any other standards mentioned in this Specification. The Contractor may submit for approval, equipment or materials conforming to technically equivalent National Standards. In such cases copies of the relevant Standards or part thereof, in the English language shall be submitted with the Tender. In case of conflict the order of precedence shall be (1) IEC, (2) IS and (3) other alternative standard.

The supply and erection requirements and procedures to be followed during the installation of the equipment shall be in accordance with the relevant Indian/International Standards/Regulations, ASME codes, accepted good engineering practice, drawings and other applicable Indian codes and laws and regulations.
Reference to a particular standard or recommendation in this Specification does not relieve the Contractor of the necessity of providing the Contract Works complying with other relevant standards or recommendations.
The list of standards provided in the Chapter 1 of this Specification is not to be considered exhaustive and the Contractor shall ensure that equipment supplied under this contract meets the requirements of the relevant standard whether or not it is mentioned therein.

**3.7.7. LANGUAGE AND SYSTEM OF UNITS**

The English language shall be used in all written communications between the Employers, AEGCL and the Contractor with respect to the services to be rendered and with respect to all documents and drawings procured or prepared by the Contractor pertaining to the work, unless otherwise agreed by the Employer.
It is required that danger plates, equipment designation labels or plates, instruction notices on plant and general substation notices be written in English. Control switch and lamp labels, indicator lamp and annunciator inscriptions shall be in English only.
The design features of all equipment shall be based on the SI system of units.

**3.7.8. MASS AND SIZE OF PARTS AND QUANTITIES OF OIL**

The mass and dimensions of any item of equipment shall not exceed the figures stated in the Schedules.
Each item shall be labeled to indicate its mass, quantity of oil (if any) and any special handling instructions.

**3.7.9. GENERAL REQUIREMENTS**

**3.7.9.1Bolts and nuts**

All bolts, studs, screw threads, pipe threads, bolt heads and nuts shall comply with the appropriate national standards for metric threads, or the technical equivalent.
Except for small wiring, current carrying terminal bolts or studs, for mechanical reasons, shall not be less than 6 mm in diameter.
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 bolts, nuts and washers placed in outdoor positions shall be treated to prevent corrosion, by hot dip galvanising or electro galvanising to service condition 4. Appropriate precautions shall be taken to prevent electrolytic action between dissimilar metals.
Where bolts are used on external horizontal surfaces 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 its nut, except when otherwise approved for terminal board studs or relay stems. If bolts and 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.

**3.7.10. Galvanising**

**3.7.10.1 General**

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.

**3.7.10.2 Galvanising**

All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use shall be hot dip galvanised. High tensile steel nuts, bolts and spring washers shall be electro galvanised to service condition 4. All steel conductors including those used for earthing and grounding (above ground level) shall also be galvanised according to IS 2629.
All galvanising shall be applied by the hot dip process and shall comply with IS 2629, IS 2633, IS 4759, IS 1367 or IS 6745.

All welds shall be de-scaled, all machining carried out and all parts shall be adequately cleaned prior to galvanising. The preparation for galvanising and the galvanising itself shall not adversely affect the mechanical properties of the coated material.

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 specially approved by AEGCL. All nuts shall be galvanised with the exception of the threads which shall be oiled. Surfaces which are in contact with oil shall not be galvanised or cadmium plated.

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

Galvanising of wires shall be applied by the hot dip process and shall meet the requirements of IS 2141.

The minimum weight of the zinc coating shall be 610 gm/sq. m. and minimum thickness of coating shall be 86 microns for all items thicker than 5 mm. For items of less than 5 mm thickness requirement of coating thickness shall be as per BS 729. For surface which shall be embedded in concrete, the zinc coating shall be a minimum of 800 gm/sq. m.

The galvanised surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects such as discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

After galvanising no drilling or welding shall be performed on the galvanised parts of the equipment excepting that nuts may be threaded after galvanising. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanisation.

The galvanised steel shall be subjected to six one-minute dips in copper sulphate solution as per IS 2633.

Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanising tests should essentially be performed as per relevant Indian Standards.

- Coating thickness
- Uniformity of zinc
- Adhesion test
- Mass of zinc coating

Galvanised material must be transported properly to ensure that galvanised surfaces are not damaged during transit. Application of zinc rich paint at site shall not be allowed.

**3.7.11. Cleaning, painting and topicalization**

**3.7.11.1 General**

All paints shall be applied in strict accordance with the paint manufacturer's instructions.

All painting shall be carried out on dry and clean surfaces and under suitable atmospheric and other conditions in accordance with the paint manufacturer's recommendations.

An alternative method of coating equipment such as with epoxy resin-based coating powders will be permitted, subject to the approval of AEGCL, and such powders shall comply with the requirements of IEC 455. The Contractor shall provide full details of the coating process to AEGCL for approval.

It is the responsibility of the Contractor to ensure that the quality of paints used shall withstand the tropical heat and extremes of weather conditions specified in the schedules. The paint shall not peel off, wrinkle, be removed by wind, storm and handling on site and the surface finish shall neither rust nor fade during the service life of the equipment.

The colours of paints for external and internal surfaces shall be in accordance with the approved colour schemes.

**3.7.11.2 Works painting processes**

All steelworks, plant supporting steelworks and metalwork, except galvanised surfaces or where otherwise specified, shall be shot blasted to BS 7079 or the equivalent ISO standard. All sheet steel work shall be degreased, pickled, phosphated in accordance with the IS 6005 "Code of Practice for phosphating iron and sheet steel". All surfaces shall then be painted with one coat of epoxy zinc rich primer, two pack type, to a film thickness of 50 microns. This primer shall be applied preferably by airless spray and within twenty minutes but not exceeding one hour of shot blasting.

All rough surfaces of coatings shall be filled with an approved two pack filler and rubbed down to a smooth surface.
The interior surfaces of all steel tanks and oil filled chambers shall be shot blasted in accordance with BS 7079 or the equivalent ISO, and painted within a period of preferably twenty minutes, but not exceeding one hour with an oil resisting coating of a type and make to the approval of AEGCL.
The interior surfaces of mechanism chambers, boxes and kiosks, after preparation, cleaning and priming as required above, shall be painted with one coat zinc chromate primer, one coat phenolic based undercoating, followed by one coat phenolic based finishing paint to a light or white colour. For equipment for outdoor use this shall be followed by a final coat of anti-condensation paint of a type and make to the approval of AEGCL, to a light or white colour. A minimum overall paint film thickness of 150 microns shall be maintained throughout.
All steelworks and metalwork, except where otherwise specified, after preparation and priming as required above shall be painted with one coat metallic zinc primer and two coats of micaceous iron oxide paint followed by two coats of either phenolic based or enamel hard gloss finished coloured paint to the approval to an overall minimum paint film thickness of 150 microns.
Galvanised surfaces shall not be painted in the works.
All nuts, bolts, washers etc., which may be fitted after fabrication of the plant shall be painted as described above after fabrication.
The painted metal works shall be subjected to paint qualification test as per draft ANSI/IEEE-Std. 37.21-1985 clause 5.2.5.

**3.7.11.3 Site painting**

After erection at site, the interior surfaces of mechanism chambers and kiosks shall be thoroughly examined, and any deteriorated or mechanically damaged surfaces of such shall be made good to the full Specification described above.
After installation/erection at site all surfaces of steelworks and metalwork shall be thoroughly washed down. Any deteriorated or otherwise faulty paint-work removed down to bare metal and made good to the full Specification described above, then painted one further coat of phenolic based undercoating and one coat phenolic based hard gloss finishing paint to provide an overall minimum paint film thickness of 200 microns.
Any nuts, bolts, washers, etc., which have been removed during site erection, or which may be required to be removed for maintenance purposes shall be restored to their original condition.
All paint work shall be left clean and perfect on completion of the works.

**3.7.12. Colour Schemes**

The Contractor shall propose a colour scheme for the sub-station for the approval of AEGCL. The decision of AEGCL shall be final. The scheme shall include:

- Finishing colour of indoor equipment
- Finishing colour of outdoor equipment
- Finish colour of all cubicles
- Finishing colour of various auxiliary system equipment including piping.
- Finishing colour of various building items.

All steel structures, plates etc. shall be painted with non-corrosive paint on a suitable primer. It may be noted that normally all Employer's electrical equipment in Employer's switchyard is painted with shade 631 of IS: 5 and Employer will prefer to follow the same for this project also. All indoor cubicles shall be of same colour scheme and for other miscellaneous items colour scheme will be subject to the approval of AEGCL.

| Sl. No. | Equipment | Application Environment | | | |
|---|---|---|---|---|---|
| | | Indoor | | Outdoor | |
| | | Colour | Code IS:5 | Colour | Code IS:5 |
| 400kV/220kV/132kVClassEquipment | | | | | |
| 1 | Transformers | — | — | Light grey | 631 |
| 2 | Marshalling boxes, CTs, PT's, CVT's, surge counter casings, junction boxes etc. | Light Admiralty grey. | 697 | Light Admiralty grey. | 697 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | Control and relay panels, PLCC cabinets etc. | Smoke grey | 692 | — | — |
| 4 | Porcelain parts i.e., insulators | Dark brown | 412 | Dark brown | 412 |
| 5 | All structures/metallic parts exposed to atmosphere | Hot dip galvanised | | | |
| **33kVClassequipment** | | | | | |
| 6 | Switch gear cubicles | Smoke grey | 692 | Light grey | 631 |
| 7 | Control and relay panels | Smoke grey | 692 | — | — |
| | LT switchgear | | | | |
| 8 | LT switch gear exterior | Smoke grey | 692 | Light grey | 631 |
| 9 | ACDB/MCC | Smoke grey | 692 | Light grey | 631 |
| 10 | DCDB | Smoke grey | 692 | — | — |
| 11 | LT busduct in side enclosure | Matt Paint | | — | — |
| 12 | LT busduct outside enclosure | Smoke grey | 692 | — | — |
| 13 | Motors | Smoke grey | 692 | Light grey | 631 |
| 14 | Diesel generator engine | Smoke grey | 692 | — | — |
| 15 | Diesel generator | Smoke grey | 692 | — | — |
| 16 | LT transformers | Smoke grey | 692 | Light grey | 631 |
| 17 | Battery charger | Smoke grey | 692 | — | — |
| 18 | Mimic diagram<br>400kV<br>220kV<br><br>132kV<br>33kV<br>11kV<br><br>415V | <br>Dark violet Golden<br>yellow<br><br>Sky blue<br>Signal red<br>Canary yellow<br><br>Middle brown | <br>796<br>356<br><br>101<br>537<br>309<br><br>411 | <br>—<br>—<br><br>—<br>—<br>—<br><br>— | <br>—<br>—<br><br>—<br>—<br>—<br><br>— |
| | Miscellaneous | | | | |
| 19 | Control modules and console inserts | Smoke grey | 692 | Light grey | 631 |
| 20 | Lighting package equipment outside | Light grey | 631 | Light grey | 631 |
| 21 | Lighting package equipment inside | Glossy white | | Glossy white | |
| 22 | Waterpipes | sea green | 217 | sea green | 217 |
| 23 | Air pipes | Sky blue | 101 | Sky blue | 101 |
| 24 | Transformer oil pipes | Light brown | 410 | Light brown | 410 |
| 25 | Fire Installations | Fire red | 536 | Fire red | 536 |
| 26 | Insulating oil/ gas treatment plant | Gulf red | 473 | Gulf red | 473 |

Table: Recommended colour schemes

**The above specifications are general guidelines. If specific requirement is made for individual items, that will supersede the above details.**

**3.7.13. Provision for exposure to hot and humid climate**

Outdoor equipment supplied under the Specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipment located in non-air-conditioned areas shall also be of same type.

**3.7.13.1 Anti-condensation Provisions:**

Space heaters where provided shall be suitable for continuous operation at 240V supply voltage. On- off switch and fuse shall be provided.

One or more adequately rated permanently or thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the lower portion of the compartment and

electrical connections shall be made from below the heaters to minimise deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature at approximately 10C, above the outside air temperature to prevent condensation. This shall be demonstrated by tests.

**3.7.13.2 Fungistatic treatment**

Besides the space heaters, special moisture and fungus resistant varnish shall be applied to parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface or part where the treatment will interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

**3.7.13.3 Ventilating specifications**

In order to ensure adequate ventilation, compartments shall have ventilation openings provided with fine wire mesh of brass or galvanised steel to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust. Outdoor compartment openings shall be provided with shutter type blinds.

**3.7.13.4 Labels and plates**

All apparatus shall be clearly labeled indicating, where necessary, its purpose and service positions. Each phase of alternating current and each pole of direct current equipment and connections shall be coloured in an approved manner to distinguish phase or polarity.

The material of all labels and the dimensions, legend, and method of printing shall be to approval. The surface of indoor labels shall have a matt 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 red lettering on a white background.

All labels and plates for outdoor use shall be of non-corroding material. Where the use of enameled iron plates is approved, the whole surface including the back and edges, shall be properly covered and resistant to corrosion. Protective washers of suitable material shall be provided front and back on the securing screws.

Labels 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. Any other relevant information which may be required for groups of smaller items for which this is not possible e.g., switch bays etc. a common name plate in English and Assamese with the title and special instructions on it shall be provided.

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

All equipment mounted on front and rear sides as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved.

On the top of each panel on front as well as rear sides large name plates with bold size lettering shall be provided for circuit/ feeder/ cubicle box designation.

All front mounted equipment shall be also provided, at the rear, with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate tracing of the wiring. The name plates shall be mounted directly by the side of the respective equipment wiring.

Name plates of cubicles and panels may be made of non-rusting metal or 3 ply lamicoid. These name plates may be black with white engraved lettering.

The name plate inscription and size of name plates and letters shall be submitted to AEGCL for approval.

The nameplates of the apparatus shall include, at least, the information listed below, together with any other relevant information specified in the applicable standards:

- Concise descriptive title of the equipment
- Rating and circuit diagrams
- Manufacturer's name, trademark, model type, serial number
- Instruction book number
- Year of manufacture
- Total weight (for capacitor racks indicate weight, for capacitors indicate quantity of liquid)
- Name of the project.

Each measuring instrument and meter shall be prominently marked with the quantity measured e.g. kV, A, MW etc. All relays and other devices shall be prominently marked with manufacturers name, manufacturer's type, serial number and electrical rating data.

Danger plates and plates for phase colours shall be provided as per requirement. The Contractor shall devise a system to designate equipment and sub-systems. The nameplates/labels displaying these designations shall

be installed at appropriate locations. Whenever motion or flow of fluids is involved, plates showing direction of motion or flow shall also be provided.

**3.7.13.5 Pad Locks**

For each item of plant, the Contractor shall provide a pad lockable handle and a non-ferrous padlock with different key changes in order to prevent access to control cabinets, cubicles and relay panels. The Contractor shall provide two keys for each lock and a master key for each substation.

Cabinets for the accommodation of padlocks and keys, whilst not in use, shall be provided and shall be suitably labeled so that keys will be readily identifiable.

**3.7.13.6 Earthing**

Metal parts of all equipment other than those forming part of an electrical circuit shall be connected directly to the main earth system via two separate conductors of adequate capacity at two different points.

All main members of structural steelworks shall be earthed by galvanised iron flat connections bonded by welding or bolting to the steelworks.

Connections to apparatus and structures shall be made clear of ground level, preferably to a vertical face and protected as appropriate against electrolytic corrosion. They shall be made between clean surfaces and of sufficient size and pressure to carry the rated short circuit current without damage.

Earth bars installed directly into the ground should normally be laid bare and the trench backfilled with a fine top soil. Where the soil is of a hostile nature, special precautions must be taken to protect the earth bar, the method used being subject to the agreement of AEGCL.

Joints in earth bars shall be welded and then coated with a suitable anti-corrosion protection treatment.

Facilities shall be provided on the earth bar run between equipment and the base of structures, comprising a looped strip, so as to permit the attachment of portable earth connections for maintenance purposes.

The cross-sectional area of the earth bar and connections shall be such that the current density is not greater than 100 A/mm2 for a 3 second fault duration or shall be decided based on the system fault rating & conductor sizing calculations as per relevant standards.

**3.7.13.7 Lubrication**

Bearings which require lubrication either with oil or grease shall be fitted with nipples.

**3.7.14. PRODUCTION PROCESS REQUIREMENTS**

**3.7.14.1 Castings**

**3.7.14.1.1. General**

All castings shall be true to pattern, free from defects and of uniform quality and condition. The surfaces of castings which do not undergo machining, shall be free from foundry irregularities. The castings shall be subject to NDT, chemical, mechanical and metallographic tests. Details of the same shall be furnished to AEGCL for review/approval. Magnetic particle inspection (MPI) test, wherever applicable, shall be carried out in longitudinal and transverse direction to detect radial and axial cracks.

**3.7.14.1.2. Iron castings**

Iron casting material shall be in accordance with ASTM A 126 Class B. A copy of the ladle analysis shall be sent to AEGCL. Each casting shall have a test bar from which tension test specimens may be taken. Test specimen shall be in accordance with ASTM A 370 and tested in accordance with ASTM E8. The Contractor shall submit his procedures for testing and acceptance for iron castings for approval by AEGCL.

**3.7.14.1.3. Steel castings**

Steel castings shall be manufactured in accordance with ASTM A 27 and shall be subjected to appropriate tests and inspection as detailed herein.

Copies of mandatory documentation, such as ladle analyses and mechanical test results, shall be sent to AEGCL. (Non-ferrous casting material and castings shall be manufactured in accordance with the appropriate ASTM standards for the material concerned).

**3.7.14.2. Forgings**

When requested by AEGCL, forgings will be subjected to inspection in the regions of fillets and changes of section by suitable method. Magnetic particle, dye-penetration, radiographic or ultrasonic, or any combination of these methods may be used to suit material type and forging design.

The testing is to be carried out after the rough machining operation and is to be conducted according to the appropriate ASTM standards.

MPI test on forging shall be carried out to detect both radial and axial cracks. Ferrous forgings shall be demagnetised after such tests.

Any indentations which prove to penetrate deeper than 2.5% of the finished thickness of the forging shall be reported to AEGCL giving location, length, width and depth. Any indentations which will not machine out during final machining shall be gouged out and repaired using an approved repair procedure.

Repair of rotating elements by welding will only be accepted subject to detailed examination of the proposal by AEGCL prior to the repair being carried out.

The forging shall be tested for mechanical and metallographic tests as per ASTM. The details shall be mutually discussed/agreed upon.

**3.7.14.3. Fabricated components**

All components machined or fabricated from plate, sheet or bar stock shall meet the material requirements of ASTM or material specification approved by AEGCL.

Structural steel, rolled shapes, bars, etc. shall comply with the latest ASTM for A36.

Plate steel shall be of a designation and quality suitable for the function it is intended to perform. Insofar as it is compatible with its function, it shall comply with ASTM A283 structural quality.

All, or a representative number of such components, shall be subjected to one or more of the following tests: visual, dye penetration, magnetic particle (transverse and longitudinal), ultrasonic or radiographic. These tests shall be in accordance with the recommended practices of the ASTM. The terms of reference for acceptance shall be the applicable ASTM Specifications.

**3.7.14.4. Welding and welder's qualifications**

**3.7.14.4.1. General**

All welding shall be carried out by qualified welders only. All welding shall be in accordance with the corresponding standards of the American Welding Society or the American Society of Mechanical Engineers. Other standards to determine the quality of welding process and qualifications of welders may be considered, provided that sufficient information is first submitted for the approval of AEGCL. Prior to the start of fabrication, the Contractor shall submit to AEGCL for approval, a description of each of the welding procedures which he proposes to adopt, together with certified copies of reports of the results from tests made in accordance with these procedures. The Contractor shall be responsible for the quality of the work performed by his welding organisation. All welding operators, to be assigned work, including repair of casting, shall pass the required tests for qualification of welding procedures and operators. AEGCL reserves the right to witness the qualification tests for welding procedures and operators and the mechanical tests at the samples. The Contractor shall bear all his own expenses in connection with the qualification tests. If the work of any operator at any time appears questionable, such operator will be required to pass appropriate pre- qualification tests as specified by the Inspector and at the expense of the Contractor.

**3.7.14.4.2. Welding**

All welding shall be performed in accordance with the appropriate standards. The design and construction of welded joints subject to hydraulic pressure shall conform to the applicable requirement of ASME "Boiler and Pressure Vessel Code" shall be qualified in accordance with Section IX of this Code. The design and construction of welded joints not subjected to hydraulic pressure shall, as a minimum, conform to the requirements of AWS "Specification for Welded Highway and Railway

Bridge" D2.0. Except for minor parts and items specifically exempted from stress relieving, all shop- welded joints shall be stress relieved in accordance with the requirements of the ASME "Boiler and Pressure Vessel Code" Section VIII.

In addition to satisfying the procedural and quality requirements set forth in the applicable code and/or these Specifications, all welding shall meet the following requirements for workmanship and visual quality:

- Butt welds shall be slightly convex, of uniform height and shall have full penetration.
- Fillet welds shall be of the specified size, with full throat and legs of equal length.
- Repairing, chipping and grinding of welds shall be done in a manner which will not gouge, groove or reduce the thickness of the base metal.
- The edges of the member to be joined shall expose sound metal, free from laminations, surface defects caused by shearing or flame-cutting operations or other injurious defects.

Welded joints subject to critical working stress shall be tested by approved methods of non-destructive testing, such as radiographic and ultrasonic examination, magnetic particle and liquid penetration inspection. All

expenses in connection with these tests shall be borne by the Contractor. The extent of testing shall be as stipulated by the ASME "Boiler and Pressure Vessel Code", Section VIII, but without prejudice to the rights of the Inspector or AEGCL to ask for additional tests,

The arc-welding process to be used and the welding qualifications of the welders employed on the work shall be used in accordance with AWS requirements and Section VIII and IX of the ASME (American Society of Mechanical Engineers) Code, latest edition, as they may apply. All welding rods shall conform to the requirements of the latest issue of Section It, part C of the ASME Code.

Gas shielded welding (TIG or MIG) used as appropriate for aluminium, stainless steel or other material shall be carried out in accordance with the best commercial practice and the following standard specifications:

- Specifications for copper and copper-alloy welding rods (AWS A5.7, ASTM B259)
- Specification for corrosion-resisting chromium and chromium-nickel steel welding rods and bare electrodes (AWS A5.9, ASTM A371)
- Specifications for aluminium and aluminium alloy rods and bare electrodes (AWS A5.10, ASTM B285).
- Specifications for nickel and nickel-base alloy bare welding filler metal (AWS A5.14, ASTM B304).

Gas welding will not normally be used in the equipment. When a particular equipment manufacture requires the use of gas welding, the proposed process and the welder's qualification shall be in accordance with AWS B3.0. Welding of galvanised components will not be allowed in the equipment. Strict measures of quality control shall be exercised throughout the Equipment/ Works. AEGCL may call for an adequate NDT test of the work of any operator, who in his opinion is not maintaining the standard of workmanship. Should this NDT test prove defective, all work done by that operator, since his last test shall be tested at the Contractor's expense. If three or more of these tests prove defective, the operator shall be removed from the project. A procedure for the repair of defects shall be submitted to AEGCL for his approval prior to any repairs being made.

**3.7.14.4.3. Welding of pipes**

Before welding, the ends shall be cleaned by wire brushing, filing or machine grinding. Each weld-run shall be cleaned of slag before the next run is deposited. Welding at any joint shall be completed uninterrupted. If this cannot be followed for some reason, the weld shall be insulated for slow and uniform cooling. Welding shall be done by manual oxy-acetylene or manual shielded metal are process. Automatic or semi-automatic welding processes may be done only with the specific approval of AEGCL. As far as possible, welding shall be carried out in flat position. If not possible, welding shall be done in a position as close to flat position as possible. Downward technique is not allowed while welding pipes in horizontal position, unless permitted by AEGCL. Combination of welding processes or usage of electrodes of different classes or makes in a particular joint shall be allowed only after the welding procedure has been duly qualified and approved by AEGCL. No backing ring shall be used for circumferential butt welds. Welding carried out in ambient temperature of 5C or below shall be heat treated.

A spacer wire of proper diameter may be used for weld root opening but must be removed after tack welding and before applying root run.

Tack welding for the alignment of pipe joints shall be done only by qualified welders. Since tack welds form part of final welding, they shall be executed carefully and shall be free from defects. Defective welds shall be removed prior to the welding of joints.

Electrodes size for tack welding shall be selected depending upon the root opening. Tack welds should be equally spaced.

Root run shall be made with respective electrodes/filler wires. The size of the electrodes shall not be greater than 3.25 mm (10 SWG) and should preferably be 2.3 mm (12 SWG). Welding shall be done with direct current values recommended by the electrode manufacturers.

Upward technique shall be adopted for welding pipes in horizontally fixed position. For pipes with wall thickness less than 3 mm, oxyacetylene welding is recommended.

The root run of butt joints shall be such as to achieve full penetration with the complete fusion of root edges. The weld projection shall not exceed 3 mm inside the pipe.

On completion of each run craters, weld irregularities, slag etc. shall be removed by grinding or chipping.

During the process of welding, all movements, shocks, vibration or stresses shall be carefully avoided in order to prevent weld cracks.

Fillet welds shall be made by shielded metal arc process regardless of thickness and class of piping. Electrode size shall not exceed 10 SWG. (3.25 mm). At least two runs shall be made on socket weld joints.

### 3.7.15. WIRING, CABLING AND CABLE INSTALLATION

#### 3.7.15.1 Cubicle wiring

Panels shall be complete with interconnecting wiring between all electrical devices in the panels. External connections shall be achieved through terminal blocks. Where panels are required to be located adjacent to each other all inter panel wiring and connections between the panels shall be carried out internally. The Contractor shall furnish a detailed drawing of such inter panel wiring. The Contractor shall ensure the completeness and correctness of the internal wiring and the proper functioning of the connected equipment.

All wiring shall be carried out with 1.1 kV grade, PVC/XLPE insulated, single core, stranded copper wires. The PVC shall have oxygen index not less than '29' and Temperature index not less than 250°C (for XLPE cable). The wires shall have annealed copper conductors of adequate size comprise not less than three strands

The minimum cross-sectional area of the stranded copper conductor used for internal wiring shall be as follows:

- All circuits excepting CT circuits and energy metering circuit of VT 2.5 sq.mm
- All CT circuits and metering circuit of VT 2.5sq. mm

All internal wiring shall be supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters and troughs shall be used for this purpose.

Cubicle connections shall be insulated with PVC to IEC 227. Wires shall not be jointed or teed between terminal points.

Bus wires shall be fully insulated and run separately from one another. Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panels running throughout the entire length of the panel suite. Longitudinal troughs extending throughout the full length of panel shall be preferred for inter panel wiring.

All inter-connecting wires between adjacent panels shall be brought to a separate set of terminal blocks located near the slots of holes meant for the passage of the inter-connecting wires. Interconnection of adjacent panels on site shall be straightforward and simple. The bus wires for this purpose shall be bunched properly inside each panel.

Wire termination shall be made with solder less crimping type and tinned copper lugs which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. Numbers 6 and 9 shall not be included for ferrules purposes unless the ferrules have numbers underscored to enable differentiation. (i.e., 6 and 9)

Fuses and links shall be provided to enable all circuits in a cubicle, except a lighting circuit, to be isolated from the bus wires.

The DC trip and AC voltage supplies and wiring to main protective gear shall be segregated from those for back-up protection and also from protective apparatus for special purposes. Each such group shall be fed through separate fuses from the bus wires. There shall not be more than one set of supplies to the apparatus comprising each group. All wires associated with the tripping circuits shall be provided with red ferrules marked "Trip".

It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard dead.

The insulation material shall be suitably coloured in order to distinguish between the relevant phases of the circuit.

When connections rated at 380 volt and above are taken through junction boxes they shall be adequately screened and "DANGER" notices shall be affixed to the outsides of junction boxes or marshalling kiosk.

Where connections to other equipment and supervisory equipment are required, the connections shall be grouped together.

**The above specifications are general guidelines. If specific requirement is made for individual items, that will supersede the above details.**

#### 3.7.15.2 LV power cabling

LVAC cable terminals shall be provided with adequately sized, hot pressed, cast or crimp type lugs. Where sweating sockets are provided, they shall be without additional clamping or pinch bolts. Where crimp type lugs are provided, they shall be applied with the correct tool and the crimping tool shall be checked regularly for correct calibration. Bi-metallic joints between the terminals and lugs shall be provided where necessary.

Terminals shall be marked with the phase colour in a clear and permanent manner.

A removable gland plate shall be provided by the Contractor. The Contractor shall be responsible for drilling the cable gland plate.

Armoured cables shall be provided with suitable glands for terminating the cable armour and shall be provided with an earthing ring and lug to facilitate connection of the gland to the earth bar.

**The above specifications are general guidelines. If specific requirement is made for individual items, that will supersede the above details.**

**3.7.15.3 Multi-core cables and conduit wiring**

External multi-core cabling between items of main and ancillary equipment shall form part of the Contract Works and shall consist of armoured multi-core cable with stranded copper conductors PVC/XLPE insulated and PVC over sheathed complying with the requirements of IEC 227 and 228 as applicable.

Multi-core cable for instrumentation and control purposes shall be supplied with 2.5 mm2 stranded copper cores. Multi-core cables for CT and VT circuits shall be supplied with two by 2.5 mm2 stranded copper cores and the cores shall be identified by the phase colour.

Where conduit is used the runs shall be laid with suitable falls and the lowest parts of the run shall be external to the equipment. All conduit runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.

Multi-core cable tails shall be so bound that each wire may be traced to its cable without difficulty. All multi-core cables shall be provided with 20 % spare cores and the spare cores shall be numbered and terminated at a terminal block in the cubicle. Where cables are terminated in a junction box and the connections to a relay or control cubicle are continued in conduit, the spare cores shall be taken through the conduit and terminated in the cubicle. The dc trip and ac voltage circuits shall be segregated from each other as shall the circuits to main protective gear be segregated from those for back-up protection.

The screens of screened pairs of multi-core cables shall be earthed at one end of the cable only. The position of the earthing connections shall be shown clearly on the diagram.

All wires on panels and all multi-core cable cores shall be crimped with the correct size of crimp and crimping tool and will have ferrules which bear the same number at both ends. 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. The same ferrule number shall not be used on wires in different circuits on the same panels.

The Contractor shall provide a two (2) meters loop of spare cable at both ends of all multi-core cable runs and shall leave sufficient lengths of tails at each end of the multi-core cables to connect up to the terminal boards. The Contractor shall also strip, insulate, ring through and tag the tails and shall also seal the cable boxes. The Contractor shall be responsible for re-checking the individual cores and for the final connecting up and fitting of numbered ferrules within all equipment provided on this contract.

The drilling of gland plates, supply and fitting of compression glands and connecting up of power cables included in the Contract scope of work shall be carried out under this contract.

**3.7.15.4 Laying and installing of cables**

**3.7.15.4.1. General**

For cable laying the following shall apply:

- Switchyard area in concrete cable troughs (cable trench having cable racks with cable Trays)
- Control Room On cable racks consisting of slotted type and ladder type cable trays
- Buildings Conduits

Directly buried cables shall be used wherever necessary with the approval of AEGCL.

**3.7.15.4.2. Laying of cable**

Cables shall be laid in concrete troughs provided under this contract or drawn into pipes or ducts or on cable racks or directly buried as may be required by AEGCL. Concrete troughs shall be designed so that the cables are supported on cable support systems and the supports shall be arranged so as to allow the segregation of power, control (including CT and VT circuits) and communications cables onto different layers of cable supports. All cable supports shall be earthed in accordance with IS 3043. The minimum vertical separation between layers of cable tray shall be not less than 300 mm.

The cable support system shall be designed and constructed to carry the required cables without undue crowding of the supports and without overloading the supports. The maximum number of layers of cable that

shall be permitted on a single cable support shall be three. The width of the cable supports shall be selected to ensure that the supports are not crowded, the cable supports are not overloaded, and that sufficient space is provided in the cable trough to allow for personnel access during and after cable installation. The width of cable supports should not exceed 750 mm.

Cables shall be laid direct in the ground only at the discretion of AEGCL. All cables laid direct in the ground outside buildings shall be laid in a trench and protected by reinforced concrete slabs or cable tiles.

For auxiliary cables the top of the slab or tile shall be at a depth not less than 300 mm below the surface of the ground and there shall be a layer of fine well packed riddled earth 75 mm thick in between the cable and the bottom of the trench and between the top of the cable and the underside of the slab.

The Contractor shall be responsible for the proper laying of all cables in the ground. Where cables in the same trench are laid over each other, they shall be separated by not less than 75 mm of riddled earth. The riddled earth used for this purpose shall have been passed through a screen having a 12 mm square mesh.

Where cables pass under roadways, they shall be laid in pipes at a depth not less than 800 mm below the surface.

The Contractor shall be responsible for the excavation of trenches which shall include all pumping and baling required and the provision of all necessary labour, plant, tools, water, additional soil, fuel or motor power for such purposes.

Cables in trenches will be inspected by AEGCL before the trenches are backfilled. Backfilling of cable trenches should be carried out as per relevant IS standards.

The running of communications and power cables along the same route shall be avoided as far as possible. Where this is not possible, they shall be segregated, the one group from the other. Power and communication cables shall be laid in separate tiers. For other than directly buried cables the order of laying of various cables shall be as follows:

- Power cables on top tiers.
- Control/ instrumentation/Communication and other service cables in bottom tiers.

**3.7.15.4.3. Cable tags and markers**

Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule. The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire conforming to IS 280. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

Location of cables laid directly in the ground shall be clearly indicated with cable marker made of galvanised iron plate.

Location of buried cable joints shall be indicated with a cable marker having an additional inscription "Cable joint".

Cable markers shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.

Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct, conduit entry and at every twenty meters (20 m) in cable tray/trench runs. Cable tags shall be provided inside switchgear, motor control centres, control and relay panels etc. and wherever required for cable identification when a number of cables enter together through a gland plate.

The price of cable tags and markers shall be included in the installation rates for cables/conduits quoted by the Bidder.

**3.7.15.4.4. Cable supports and cable tray mounting arrangements in control room**

The control room will normally be provided with embedded steel inserts on concrete floors/walls for the purpose of cabling in the control room. The supports shall be secured by welding to these inserts or available building steel structures. However, in cases where no such embedded steel inserts are available, the same shall have to secure to the supports on walls or floors by suitable anchoring.

**3.7.15.4.5. Cable support structure in switchyard cable trenches**

The contractor shall fabricate and install cable support structures in cable trenches. These supports shall be provided at 750 mm spacing along the run of cable trenches.

Cable supports and cable racks shall be fabricated from standard structural steel members, channels, angles and flats of required size. The fabrication welding and erection of these structures shall conform to the relevant clauses of this Specification, in addition to the specification given herein.

**3.7.15.5. Termination of cables and wires**

Where cables leave the apparatus in an upward direction the cable boxes shall be provided with a barrier joint to prevent leakage of cable oil or compound into the apparatus. Where cable cores are liable to contact with oil or oil vapour the insulation shall be unaffected by oil.

PVC sheathed cables shall be terminated by compression glands complying with BS 6121 (or equivalent).

Auxiliary PVC insulated cables shall be terminated with compression type glands, clamps or armour clamps complete with all the necessary fittings.

Colours shall be marked on the cable box, cable tail ends and single core cables at all connecting points and/or any positions AEGCL may determine. Cable boxes shall be provided with suitable labels indicating the purpose of the supply where such supply is not obvious or where AEGCL may determine.

All cables shall be identified and shall have phase colours marked at their termination.

All incoming and outgoing connections shall be terminated at a terminal block. Direct termination into auxiliary switches will not be accepted.

**The above specifications are general guidelines. If specific requirement is made for individual items, that will supersede the above details.**

**3.7.16.1 DEGREES OF PROTECTION**

Degrees of protection shall be provided in accordance with IEC 144 and IEC 529 and be as follows:

- For outdoor applications, IP 55/ IP 65.
- For indoor applications where purpose-built accommodation is provided, e.g., switch and control and relay rooms in auxiliary plant buildings, IP 41/42.
- Where dust can adversely affect equipment within the enclosure, this equipment should be separately housed with a degree of protection of IP 51.
- For indoor applications where the equipment is housed in the same building as that enclosing water and steam operated equipment, the degrees of protection stated in the previous paragraph shall be up rated to IP 44 and IP 54 respectively.

Where more severe environments exist, e.g., steam and oil vapour or other deleterious chemical environments, special measures will be necessary, and the degree of protection required will be specified separately.

The Contractor shall submit a schedule for providing the degree protection to various control boxes, junction boxes etc. for AEGCLs approval.

**The above specifications are general guidelines. If specific requirement is made for individual items, that will supersede the above details.**

**3.7.16.2 SUPPLY VOLTAGE**

All incoming supplies of greater than 125V to earth shall have their termination shrouded by a suitable insulating material.

The auxiliary supply voltages on site shall be as follows:

| Nominal Voltage V | Variation | Frequency Hz or DC | Phase | Wires | Neutral Connection |
|---|---|---|---|---|---|
| 430 | ±10% | 50±5% | 3 | 4 | Solidly earthed |
| 240 | ±10% | 50±5% | 1 | 2 | Solidly earthed |
| 220 | 187V-242V | DC | DC | 2 | Isolated2wires |
| 110 | 100V-121V | DC | DC | 2 | Isolated2wires |
| 50 | 45V-55V | DC | DC | 2 | +ve earthed |

**3.7.16.3 MAINTENANCE TELEPHONE POSITIONS**

Telephone jack plug points shall be provided at each circuit breaker, at each power transformer marshalling kiosk and, on each control, and relay panel. At each substation these plug points are to be connected in parallel to form a site telephone circuit for use during maintenance and testing operations.

**3.7.16.4 ERECTION CONDITIONS**

**3.7.16.4.1 General**

The following shall supplement the conditions already contained in the other parts of these specifications and documents and shall govern that portion of the work on this Contract to be performed at Site.

**3.7.16.4.2 Regulation of local authorities and statutes**

The Contractor shall comply with all the rules and regulations of local authorities during the performance of his field activities. He shall also comply with the Minimum Wages Act, 1948 and the payment of Wages Act (both of the Government of India and Govt of Assam) and the rules made there under in respect of any employee or workman employed or engaged by him or his Sub-Contractor.

The Contractor shall ensure that he obtains, from the Government of Assam, an Electrical Contractor's Licence and a supervisory certificate of the appropriate grade to allow him to execute the electrical works included in the Contract. The Contractor shall ensure that all workmen possess Workman Permits, issued by the Government of Assam, for engagement in the Contract Works.

**3.7.16.4.3 Inspection, testing and inspection certificates**

The provisions of the General Conditions of Contract shall also be applicable to the erection portion of the Works. AEGCL shall have the right to re-inspect any equipment though previously inspected and approved by him at the Contractor's works, before and after the same are erected at Site.

**3.7.16.4.4 Contractor's field operation**

**3.7.16.4.4.1 General**

The Contractor shall inform AEGCL in advance of field activity plans and schedules for carrying-out each part of the works. Any review of such plans or schedules or methods of work by AEGCL shall not relieve the Contractor of any of his responsibilities towards the field activities. Such reviews shall not be considered as an assumption of any risk or liability by the Employer or any of his representatives, and no claim of the Contractor will be entertained because of the failure or inefficiency of any such plan or schedule or method of work reviewed. The Contractor shall be solely responsible for the safety, adequacy and efficiency of plant and equipment and his erection methods.

**3.7.16.4.5 Facilities to be provided by the contractor**

**3.7.16.4.5.1. Unloading**

Contractor shall make his own arrangement for unloading the equipment at site.

**3.7.16.4.5.2. Tools, tackle and scaffoldings**

The Contractor shall provide all the construction equipment tools, tackle and scaffoldings required for offloading, storage, pre-assembly, erection, testing and commissioning of the equipment covered under the Contract. He shall submit a list of all such materials to AEGCL before the commencement of pre-assembly at Site. These tools and tackles shall not be removed from the Site without the written permission of AEGCL.

**3.7.16.4.6. First-Aid and general hygiene**

The Contractor shall provide necessary first-aid facilities for all his employees, representatives and workmen working at the site. At all times at least ten percent of all Contractors personnel assigned to the worksite shall be trained in administering first-aid.

The labour colony, offices and residential areas of the Contractor's employees and workmen shall be kept clean and neat to the entire satisfaction of AEGCL. Proper sanitary arrangements shall be provided by the Contractor in work-areas, offices and residential areas of the Contractor.

Waste oil shall be disposed of in a manner acceptable to AEGCL. Under no circumstances shall waste oil be dumped into uncontrolled drains.

**3.7.16.4.7. Security**

The Contractor shall have total responsibility for all equipment and material in his custody, stored, loose, semi-assembled and/or erected by him at Site. The Contractor shall make suitable security arrangements including employment of security personnel to ensure the protection of all materials, equipment and works from theft, fire, pilferage and any other damages and loss.

**3.7.16.4.8. Materials handling and storage**

All the equipment furnished under the Contract and arriving at Site shall be promptly received, unloaded and transported and stored in the stores by the Contractor.

Contractor shall be responsible for examining the complete shipment and notifying AEGCL immediately of any damage, shortage, discrepancy etc. for the purpose of AEGCL's information only. The Contractor shall submit to AEGCL every week a report detailing all the receipts during the weeks. However, the Contractor shall be solely responsible for any shortages or damages during transit, handling, storage and erection of the equipment at Site. Any demurrage, wharf age and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

The Contractor shall maintain an accurate and exhaustive record detailing all equipment received by him for the purpose of erection and keep such record open for the inspection of AEGCL.

All equipment shall be handled carefully to prevent any damage or loss. All equipment stored shall be properly protected to prevent damage. Equipment from the store shall be moved to the actual location at an appropriate time so as to avoid damage of such equipment at Site.

All the materials stored in the open or dusty location shall be covered with suitable weather-proof and flameproof covering material.

The Contractor shall be responsible for making suitable indoor facilities for the storage of all equipment which requires to be kept indoors.

**3.7.16.4.9. Construction Management**

**3.7.16.4.9.1. General**

Time is the essence of the Contract and the Contractor shall be responsible for performance of his Works in accordance with the specified construction schedule. If at any time the Contractor is falling behind the schedule, he shall take necessary action to make good for such delays by increasing his work force or by working overtime to accelerate the progress of the work and to comply with schedule and shall communicate such actions in writing to AEGCL, providing evidence that his action will compensate for the delay. The Contractor shall not be allowed any extra compensation for such action.

**3.7.16.4.10. Field office records**

The Contractor shall maintain at his Site office up-to-date copies of all drawings, specifications and other supplementary data complete with all the latest revisions thereto. The Contractor shall also maintain in addition the continuous record of all changes to the above contract documents, drawings, specifications, supplementary data, etc. effected at the field. On completion of his total assignment under the Contract, such drawings and engineering data shall be submitted to AEGCL in the required number of copies.

**3.7.16.4.11. Protection of property and Contractor's liability**

The Contractor will ensure provision of necessary safety equipment such as barriers, sign-boards, warning light and alarms, personal protective equipment etc. to provide adequate protection to persons and property. The Contractor shall be responsible for giving reasonable notice to AEGCL and the owners of public or private property and utilities when such property and utilities are likely to be damaged or injured during the performance of his works, and shall make all necessary arrangements with such owners, related to removal and/or replacement or protection of such property and utilities.

**3.7.16.5 EMPLOYER'S SUPERVISION**

To eliminate delays and avoid disputes and litigation, it is agreed between the Parties to the Contracts that all matters and questions shall be referred to the Employer and without prejudice the Contractor shall proceed to comply with the Employer's decision.

The work shall be performed under the direction and supervision of AEGCL& PMC. The scope of the duties of AEGCL, pursuant to the contract, will include but not be limited to the following:

- Interpretation of all the terms and conditions of these documents and specifications.
- Review and interpretation of all the Contractors drawing, engineering data etc.
- Witness or authorize his representative to witness tests and trials either at the manufacturer's works or at site, or at any place where work is performed under the Contract.
- Inspect, accept or reject any equipment, material and work under Contract.
- Issue certificate of acceptance and/or progressive payment and final payment certificates.
- Review and suggest modification and improvements in completion schedules from time to time.
- Supervise the Quality Assurance program implementation at all stages of the Works.

**3.7.16.6 TESTING AND INSPECTION**

**3.7.16.6.1General Conditions of Type Test**

The Contractor shall carry out the tests stated in accordance with the conditions of this Specification, without extra charge for such additional tests as in the opinion of AEGCL are necessary to determine that the Contract Works comply with this Specification. The tests shall be carried out generally in accordance with the relevant IEC's or IS. However, in the absence of relevant regulations in IEC / IS, other appropriate international standards may be accepted at AEGCL's discretion. The specific details of testing and inspection are given in the appropriate section of this Specification.

The Contractor shall submit Type Test Reports for all equipment excluding GIS being supplied by him (as per IEC standard) which, shall not be older than five (5) years, as on date of bid opening for AEGCL's approval. AEGCL may also give instruction to carry out Type Tests, routine tests or acceptance tests. No charges shall be paid by AEGCL for any Type Test.

**3.7.16.6.2 Mandatory Type Test for GIS Equipments (If applicable)**

The manufacturer shall furnish the certificates confirming successful conduction of the following Type Tests for GIS. The tests carried out shall not be older than Ten (10) years from the date of issue of LOA.

1. Tests to verify the insulation level (Lightning impulse, switching impulse and ac withstand test with PD) test on each GIS device (CB, Disconnector, bus etc.)
2. Dielectric tests on auxiliary circuits.
3. Tests to prove the radio interference voltage (RIV) level.
4. Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit.
5. Tests to prove the ability of the main and earthing circuits to carry the rated peak and the rated short time withstand current.
6. Tests to verify the making and breaking capacity of the included switching devices.
7. Tests to prove the satisfactory operation of the included switching devices.
8. Tests to prove the strength of enclosures.
9. Verification of the degree of protection of the enclosure.
10. Gas tightness tests
11. Electromagnetic compatibility tests (EMC).
12. Additional tests on auxiliary and control circuits.
13. Tests on partitions.
14. Tests to prove the satisfactory operation at limit temperatures.
15. Tests to prove performance under thermal cycling and gas tightness tests on insulators.
16. Corrosion test on earthing connections (if applicable).
17. Tests to assess the effects of arcing due to an internal fault.
18. Tests on solid dielectric components (operating rods, spacers, etc.)
19. Seismic test
20. Test on Auxiliary switches (Electrical & Mechanical Endurance, Heat run, IR & HV test)

All materials used shall be subjected to such routine tests as are customary in the manufacture of the types of plant included in the Contract Works. These materials shall withstand satisfactorily in all such tests.

All tests shall be carried out to the satisfaction of AEGCL, in presence of authorised representative of AEGCL, at such reasonable times as AEGCL may require, unless agreed otherwise. Not less than three weeks' notice of all tests shall be given to AEGCL in order that AEGCL may be represented if AEGCL so desires. As many tests as possible shall be arranged together. Six copies of the Contractor's test report and test sheets shall be supplied to AEGCL for approval.

Measuring apparatus shall be approved by AEGCL and if required shall be calibrated at the expense of the Contractor at an approved laboratory.

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

All apparatus, instruments and connections required for the above tests shall be provided by the Contractor, but AEGCL may permit the use for the tests on site, any instruments and apparatus which may be provided permanently on site as part of the contract works conditional upon the Contractor accepting liability for any damage which may be sustained by such equipment during the test.

The contractor shall supply suitable test pieces of all materials as required by AEGCL. If required by AEGCL, test specimens shall be prepared for check testing and forwarded at the expense of the Contractor to an independent testing authority selected by AEGCL.

Any costs incurred by the Employer in connection with inspection and re-testing as a result of a failure of the subject under test, or damage during transport, or erection on site before take-over by the Employer, shall be to the account of the Contractor.

No inspection or lack of inspection or passing by AEGCL of work, plant or materials, whether carried out or supplied by the Contractor or sub-contractor, shall relieve the Contractor from his liability to complete the Contract Works in accordance with the Contract or exonerate him from any of his guarantees.

**The above specifications are general guidelines. If specific requirement is made for individual items, that will supersede the above details.**

**3.7.16.7FIRE PRECAUTIONS**

All apparatus, connections and cabling shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire. When cabling is carried out as part of this Contract the Contractor shall be responsible for sealing all holes in floors, walls, roofs etc. through which the cabling may pass.

The work procedures that are to be used during the erection shall be those which minimise fire hazards to the maximum extent practicable. Combustible materials, combustible waste and rubbish shall be collected and removed from the site at least once each day. Fuels, oils and volatile or flammable materials shall be stored away from the construction site and equipment and material stores in appropriate safe containers.

All Contractors' supervisory personnel and at least ten percent all of workers shall be trained for fire- fighting and shall be assigned specific fire protection duties. At least ten percent of all personnel assigned to site at any one time shall be trained for firefighting.

The contractor shall provide sufficient fire protection equipment of the types and sizes for the ware- houses, office temporary structures, labour colony area etc. Access to such fire protection equipment shall be easy and kept open at all time.

**3.7.16.8PACKING, SHIPPING AND TRANSPORT**

The Contractor shall be responsible for the packing, loading and transport of the plant and equipment from the place of manufacture, whether this is at his own works or those of any Contractor, to Site, and for off-loading at site.

All apparatus and equipment shall be carefully packed for transport by air, sea, rail and road as necessary and in such a manner that it is protected against tropical climate conditions and transport in rough terrain and cross-country road conditions. The method of packing shall provide complete protection to all apparatus and equipment during transport and storage at site in heavy rain. The method of packing shall provide adequate protection to main items of plant and those parts contained within and attached without, for transportation.

Precautions shall be taken to protect parts containing electrical insulation against the ingress of moisture.

All bright parts liable to rust shall receive a coat of anti-rusting composition and shall be suitably protected. The machined face of all flanges shall be protected by means of a blank disc bolted to each face.

Where appropriate all parts shall be boxed in substantial crates or containers to facilitate handling in a safe and secure manner. Each crate or container shall be marked clearly on the outside of the case to show "TOP" and "BOTTOM" positions with appropriate signs, and where the mass is bearing and the correct position for slings. Each crate or container shall also be marked with the notation of the part or parts contained therein, contract number and port of destination. It shall be the Contractor's responsibility to dispose of all such packing.

Any damage due to defective or insufficient packing shall be made good by the Contractor at his own expense and within reasonable time when called upon by AEGCL to do so. Four (4) copies of complete packing lists showing the number, size, marks, mass and contents of each package shall be delivered to AEGCL immediately after the material is dispatched.

The Contractor 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 Contractor shall also be responsible for verifying the access facilities specified.

The Contractor shall be responsible for all costs of repair or replacement of the equipment, including those incurred by the Employer, arising from damage during transport, off-loading or erection on site, until take-over by the Employer.

The Contractor 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. Any cost of claim towards damages, if any, caused to Bridges and Highways during transportation of the materials shall be borne by the contractor.

**3.7.16.9ERECTION MARKS**

Before leaving the Contractor's Works all apparatus and fittings shall be painted or stamped in two places with a distinguishing number and/or letter corresponding to the distinguishing number and/or letter on an approved drawing and material list. All markings shall be legible; weatherproof tags, where used, shall be durable, securely attached and duplicated.

The erection marks on galvanised material shall be stamped before galvanising and shall be clearly legible after galvanising.

**3.7.16.10SPECIAL TOOLS & EQUIPMENTS**

A complete set of spanners shall be supplied for each station to fit every nut and bolt head on the apparatus supplied under this Contract, together with all special tools required for the adjustment and maintenance of the equipment. These tools shall be mounted in a lockable cabinet at each substation, also to be provided under this Contract. Eye bolts which have to be removed after use shall be accommodated in the cabinets.

Spanners and other maintenance equipment provided under the Contract shall not be used for the purpose of erection of the contract Works.

Any special devices, slings or tackle necessary for the complete overhaul of the plant shall be handed over to AEGCL in working order on completion of the Contract.

On delivering any or all of these tools to AEGCL, a signature shall be obtained from AEGCL's representative. Any tools not signed for shall be deemed not to have been delivered.

**The above specifications are general guidelines. If specific requirement is made for individual items, that will supersede the above details.**

**3.7.16.11RUNWAY BEAMS, EYE BOLTS AND LIFTING TACKLE**

Runway beams shall comply with the requirements of BS 2853, or its equivalent, and shall be tested after erection in accordance with this standard and this Specification. The Contractor shall be responsible for the provision of the appropriate test certificates which must be in accordance with Appendix C of BS 2853.

All slings, eye bolts and other lifting tackle provided shall be proof tested to twice the safe working load and suitably marked with embossed labels to show clearly the safe working loads.

**3.7.16.12EARTHING SYSTEM**

Electrical measurements of the subsoil at various depths up to 20 meters shall be made at the site of each substation in order to determine the layered effects of the ground from which the effective ground resistivity and hence the expected resistance of the proposed earth grid system may be predicted. Wenner's 4 - Electrode method as per IEEE-Std. 81 may be followed for measurement of earth resistivity. The earthing system shall comprise a mesh grid formed by hot dip galvanised iron flat bar (GI flat) of 75 X 12 mm(for 220/132 KV & 132/33 KV) and 40 mm MS rod (for 400 KV) buried directly in the ground and arranged so as to utilise fully the available site area. A continuous conductor shall be laid outside the periphery of the substation site at a distance of two meters from the switchyard fence and at a depth of at least 0.7 meters (the earth mat top shall be at 700 mm below the finished ground level) below the surface. A mesh system shall be formed by interconnection at various points to the perimeter conductor. The distance between two buried Earth Mat (flat/rod) shall be maximum 5 meters both ways. The mesh system shall be designed such that the grid potential rise limits the touch voltage to a value not greater than the maximum tolerable touch potential; the fault clearance time to be used in the earthing calculations shall be taken as one second. The earthing system shall be designed to meet the requirements of this specification and shall be in accordance with IEEE 80 and IS 3043. The Contractor shall present calculations to show the earthing system meets these requirements and can be shown to be safe in terms of touch, step and transferred potentials. The calculations shall be carried out considering a layer of crushed metals of thickness 100mm and without the same; and if applicable recommend suitable site surfacing. The resistance of the earth mat shall not exceed 0.5.

Each substation shall be provided with safety grounding mat as per clause relevant clauses of this section. While designing the ampacity of the buried conductor suitable corrosion allowance shall be considered for Thirty-Five (35) years. The conductors shall be buried at a depth of 700 mm from finished formation level. The conductors shall be welded suitably for maintaining a high degree of mechanical rigidity and electrical connectivity.

The substation earth mat shall be designed to provide a ground potential rise within safe limits of tolerable touch and step potential. The margins of limits shall confirm the international practices. The design of earth mat shall be in accordance with IEEE-80/1986 and shall be submitted to AEGCL approval.
In the event of the substation resistance obtained with the foregoing installation being of a magnitude unacceptable to AEGCL, then where practicable, the ground area enclosed by the earth system should be increased by installing directly in the ground a GI flat /MS rod conductor in the form of a ring around the site at a significant distance from the boundary fence. Alternatively, earth conductors can be directly buried radially outside the substation perimeter fence. The use of earth plates as current carrying electrodes is not acceptable.
The earthing system shall be designed so as to include all overhead line terminal towers, which shall be earthed by extending the system so as to envelope all towers within the earth system. Each tower shall be bonded directly to the earth system from at least two locations. Structures and masts for lighting and security surveillance equipment shall also be within the perimeter of the earth grid. No fixed low voltage equipment, with the exception of a warning or alarm button and intruder alarms which shall be of the double insulation type, shall be erected outside the perimeter of the earth grid.
Where a metal substation fence is provided, this shall be bonded electrically to the earthing grid on each side at spacing not exceeding 0.25r (where r is the equivalent circular plate radius), at points adjacent to each corner and immediately below any overhead line entering or leaving the Site. The location of the mesh conductors shall be such as to enable all items of equipment to be connected to the earth system via the shortest possible route.
Gate posts forming part of the substation fence shall be bonded together with below ground connections and the gates themselves shall be electrically bonded to the posts at two points through flexible braids.
The current density of the earth conductor shall be not greater than 100A/mm2. Single connections between equipment and the earth system shall carry the total short circuit current, but the cross-sectional area of branch connections may be reduced to take account of current distribution in two or more conductors. A distribution of 60 per cent shall be assumed for this purpose, i.e. the cross-sectional area of branch connections may be reduced to 60 per cent of the corresponding single conductor.
The earth conductor may be sized as per IEEE 80 and sufficient allowance for corrosion may be taken into account.
The grid voltage rise under fault conditions shall not exceed 15 kV. If the calculated grid voltage rise exceeds 430V, the local Telephone Authority shall be advised, by the Contractor, of the grid voltage rise and the distance of the 650V contour from the substation grid periphery.
The alternative approach of independently earthing the fence and placing it outside the earth grid area shall only be adopted if the above-mentioned procedures prove insufficient or impracticable. The Contractor shall provide calculations to show that this approach produces safe touch voltages at the fence and shall ensure that the fence is isolated from all other buried metalwork.
Metal parts of all equipment, other than those forming part of an electrical circuit, shall be connected directly to the main earth system at two points. For the same the size of the G.I. flats shall also be 75X10mm.This is the raiser of the earth to the structures of column, beam and all equipment structures. The arrangement of the mesh earth system shall be such as to minimise the length of these connections.
A separate set of earth electrodes (at least two), GI pipe, perforated, 50mm dia, heavy duty having 3000mm long in a treated earth pit, shall be provided for the earthing for high frequency coupling equipment (CVT etc), surge arresters, IVT, each neutral of the transformers and reactors at a position immediately adjacent to the equipment being earthed in addition to the normal earth connection.
All main members of structural steelworks shall be earthed by GI flat (size 75X10mm) earthing connections being bonded to the steelworks. The Contractor shall be responsible for earthing of the transformers and circuit breakers installed on the substation site as per recommended.
Connections to apparatus and structures shall be made clear of ground level, preferably to a vertical face and protected against corrosion.
Earth bars installed directly into the ground should normally be laid bare and the trench backfilled with a fine top soil. Where the soil is of a hostile nature, precautions must be taken to protect the earth bar.
All exposed joints shall be at a minimum height of 150 mm above floor or ground level.
A facility shall be provided on the earth bar run between the equipment and the base of the structure, comprising a looped copper strip (test link), so as to permit the attachment of portable earth connections for maintenance purposes.

After installation of the earth system the Contractor shall measure the resistance of the substation. The method used shall preferably be the "fall of potential" method, requiring the availability of a local low voltage supply, but other methods using an earth resistance meter will be acceptable in the event of a local supply being unavailable. The fencing of the switch yard also to be earthed by using G.I flats of size 75x10mm to each post and a continuous earth strip of size 50x6mm shall run all through the fence. The periphery of the switch yard shall be provided with non-treated earth pit at a distance of 5 mtrs all along the periphery. The size of the non-treated pit conductor shall be 40 mm dia MS rod of length 3000mm. The said earth MS Rod to be placed in earth pit as per standard practice and the pit shall be filled with Bentonite powder mixed with lomy soil at a ratio 1:10. There shall be provision of watering into the earth pits. A pipe of adequate size should run all along the periphery and outlets shall be provided to each pit. The pipe shall be connected to the overhead tank provided on the control room building and proper water control valve should be provided. Contractor shall prepare a detail earthing provision considering as per specification and shall obtain approval from AEGCL and the top of the MS rod shall be welded to the buried earth mats.

## 3.17. TECHNICAL SPECIFICATION OF TRANSFORMER

**3.17.1.0 SCOPE:**

**3.17.1.1.1** Design, engineering and manufacturing of one no. of 220/132/33 KV, 200 MVA Auto Transformer, testing at manufacturer's works, supply and delivery at substation site with all accessories, mandatory spares & special tools/kits. The scope also includes replacement of existing transformer with the new transformer.

**3.17.1.1.2** The new supplied transformer shall be fitted with Nitrogen Injection Fire Protection System (NIFPS), on line dissolved Hydrogen and moisture monitor, online insulating oil drying system, associated equipment including oil for first filling including wastage & 10% extra of that quantity which are required for efficient and trouble-free operation as specified hereunder.

**3.17.1.1.3** The scope also includes the supervision, erection, testing and commissioning & related works of power transformer at project site.

**3.17.1.1.4** Contractor will be required to arrange all equipment for unloading at site. It is also responsibility of the Contractor to obtain any road permits and any other permits or licenses to execute the works.

**3.17.1.2** It is not the intent to specify completely herein all details of the design and construction of equipment. However, the equipment shall conform in all respects standards of engineering, design and workmanship listed in **clause no. 3.17.2.0** and shall be capable of performing in continuous commercial operation up to the supplier's guarantee in a manner acceptable to the purchaser, who will interpret the meanings of drawings and specification and shall have the power to reject any work or material which, in his judgment, is not in accordance therewith. The equipment offered shall be complete with all components necessary for their effective and trouble-free operation. Such components shall be deemed to be within the scope of supplier's supply, irrespective of whether those are specifically brought out in this specification and/or the commercial order or not.

**3.17.1.3** The scope of supply includes the provision of training for Purchaser's personnel (Limiting to 10 Persons for minimum of 05 days duration) in regard to design, manufacture, assembly, testing, operation and maintenance of offered transformer at his works in the event of order, free of cost to AEGCL.

**3.17.2.0 STANDARDS:**

**3.17.2.1.0** The Transformer and associated accessories shall conform to the latest issues of the standards as given below, except to the extent explicitly modified in this specification.

| | |
|---|---|
| (1) CBIP manual on Transformer. | Pub. No. 295 / 317 |
| (2) 'Standard Specifications and technical Parameters for Transformers and Reactors (66 kV & above voltage class)' of CEA vide 'File No.CEA-PS-14-169/2/2019-PSETD Division Dated: April, 2021' | |
| (3) Power Transformers | IS: 2026 |
| (4) Fittings and accessories for power transformers | IS: 3639 |
| (5) Insulating oils for transformers and switchgears | IS: 335 |

| | |
|---|---|
| (6) Bushings for alternating voltages above 1000 V | IS: 2099 |
| (7) Gas operated relays | IS: 3638 |
| (8) Code of practice for installation and maintenance | IS: 10028 of transformers |
| (9) Colours for ready mix paints. | IS: 5 |
| (10) Industrial cooling fans. | IS: 6272 |
| (11) Guide for loading of oil immersed transformers. | IS: 6600 |

**3.17.2.1.1** In case equipment conforms to other international standard which ensure equivalent or better performance than that specified under **Clause 3.17.3.0,** then relevant extracts of the same shall be forwarded with the bid and the salient features of comparison shall be brought out separately in additional information schedule.

**3.17.2.1.2** For further reference regarding standards **Annexure-T (List of Codes/Standards/ Regulations/Publications [latest amendments])** shall be followed.

**3.17.3.0. GENERAL REQUIREMENT:**

**3.17.3.1.0** The transformers shall conform in all respects to high standards of engineering, design, workmanship and 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 judgment, is not in full accordance therewith.

**3.17.3.1.1** The Transformer offered by the contractor shall at least conform to the requirements specified under relevant IS/IEC standard. In case of discrepancy between IS and other international standard, provisions of IS shall prevail. If the IS standard is not available, then other applicable international standard (IEC/Equivalent), as per the specification, shall be accepted.

**3.17.3.1.2** The equipment to be supplied against this specification shall be suitable for satisfactory continuous operation under the tropical conditions mentioned in General Technical Requirement (GTR), of this bidding document.

**3.17.3.1.3** The transformers shall in general have constant ohmic impedance between HV and IV on all taps. However, in case of transformer to be connected for parallel operation:

i) The percentage impedance, vector group, OLTC connection and range etc. of the transformers shall be matched.

ii) Necessary provision is to be kept in the transformer control scheme for parallel operation with the OLTC control scheme having provision of Master/Follower/Independent /Off operation etc.

iii) External or internal reactors shall not be used to achieve the specified HV/LV and IV/LV impedances.

**3.17.3.1.4** The Transformer shall be multi-winding, oil immersed complying as per Specific technical parameters and suitable for outdoor installation.

**3.17.3.1.5**The transformer of manufacturer having same or higher MVA rating and same or higher voltage class must be in successful operation in any STATE or CENTRAL utility for not less than five (5) years as on date of NIT.

**3.17.3.1.6**Components having identical rating shall be interchangeable.

**3.17.3.1.7 Rated Capacity and Voltage of the Transformers as per present requirement of AEGCL:**

200 MVA - 220/132/33 KV Auto Transformer with loaded 33 KV tertiary winding.

**3.17.4.0. SPECIFIC REQUIREMENT:**

**(i) Type Test:**

This clause has reference to bid document Clause 1.1, Appedix-2 of ITB, Section-1, 'Evaluation and Qualification Criteria'.
The transformers should be Type Tested as per IS 2026 or IEC 60076 in conjunction with their relevant Part. Necessary test documents of previously tested similar or higher rated (both in MVA and voltage class) transformer shall have to be submitted with the bid.

Materials, which have never been tested for critical performance, shall not be accepted. In such cases, a promise or agreement by a bidder to have the equipment tested after award of a contract is not acceptable.

All Bids must be accompanied by the Type Test Certificates of materials offered. Type test certificates shall be acceptable only if: -

(a) Tests are conducted in an independent and well known (**NABL**/**BIS** Accredited) testing laboratory, or
(b) Tests are conducted in manufacturer's own laboratory. In this case,
    (i) The laboratory must have ISO 9000 (or its equivalent) series certification; and
    (ii) Tests have been witnessed by technically qualified representatives of earlier clients or purchaser.

Test reports to be acceptable must be related directly to the materials offered. Test reports for higher class of equipment are acceptable with commitment to perform the type tests free of any charge on the particular equipment(s) after the award of contract.

**The Validity of type test report of Power/Auto Transformer shall be as per CEA's "Guideline for Validity period of Type Tests conducted on Major Electrical Equipment in power transmission system", file No CEA-PS-14-80/1/2019-PSETD Division- Part (2) and CEA's notification no. CEA-TH-17/1/2021-TETD Division—dated 23rd December, 2022.**

Full Type Test Reports of at least the following equipment must be submitted: -

1. **200 MVA Auto Transformer**
2. **Tap Changer**
3. **Transformer Oil**
4. **Bushings**
5. **Buchholz Relay**
6. **Pressure Relief Device**
7. **Bushing Current Transformer**
8. **Oil Surge Relay**
9. **Cooling Gears**
10. **AVR Relay**
11. **On line drying system**
12. **Online moisture monitoring system**
13. **Nitrogen Fire Extinguishing & Prevention system**
14. **Maintenance free dehydrating breather**

**(ii) Dynamic Effect of Short Circuit:**

For 220 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 220 kV or above voltage class transformer within last ten years as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case bidder has not successfully tested 220 kV or

above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. The offered transformer should comply the requirement of similarity clause specified in IS 2026 (PART 5) / IEC 60076-5 with respect to short circuit tested transformer. Further, design review of offered transformer shall be carried out based on the design of short circuit tested transformer. Criteria for similar design shall be as per Annexure-J of Central Electricity Authority's "Standard Specifications and Technical Parameters for Transformers and Reactors (66kV and above)".

**(iii)Sweep Frequency Response Analysis (SFRA/FRA)** shall have to be carried out as special test for each transformer at manufacturer's premises in presence of representative of AEGCL free of cost. Test result shall have to be handed over to AEGCL. Before commissioning of the Transformer at site, the same SFRA/FRA test will have to be carried by the test engineers of the manufacturer in presence of customer's representative for comparing the results to take the decisions of the commissioning. The Testing Engineers & FRA kit for such pre-commissioning site testing shall have to be arranged by the manufacturer free of cost.

**(iv)Tests at Manufacturer's works**: The Transformers shall be subjected to type & routine test, special tests and no load & load loss measurement as per relevant IS.

**(v)Guaranteed Technical Particulars:** The Bidder shall furnish all guaranteed technical particulars as called for in this specification along with each copy of Bid submission. Bids lacking information in this respect may not be considered.

**(vi)Core Materials:** Core materials should be directly procured from either the manufacturer or their accredited reputed marketing organization and not through any agent.

**3.17.5.0. Guaranteed Technical Particulars**

**3.17.5.1.0** The Guaranteed Technical Particulars of the various items shall be furnished by the Bidders in the prescribed Schedules with the Technical Bid. The Bidder shall also furnish any other information's as in their opinion is needed to give full description and details to judge the item(s) offered by them.

**3.17.5.1.1** The data furnished in Guaranteed Technical Particulars should be the minimum or maximum value (as per the requirement of the specification) required. A Bidder may guarantee a value more stringent than the specification requirement. However, for testing purpose or from performance point of view, the material shall be considered performed successfully if it achieves the minimum/maximum value required as per the technical specification. No preference what so ever shall be given to the bidder offering better/more stringent values than those required as per specification except where stated otherwise.

**3.17.6.0. Liquidated Damages and Rejection for Excessive Losses**

**3.17.6.1.0** The no-load loss, load loss and auxiliary losses (cooler loss) as well as total losses shall be guaranteed under penalty for each transformer subject to **Clause 3.17.6.1.2** and **3.17.6.1.3**. For the purpose of penalty computation, the test figures of the no-load and the total losses of each transformer will be compared with the corresponding guaranteed figures.

**3.17.6.1.1** The no-load losses, load losses and auxiliary losses shall not exceed the values specified in the **Maximum losses** Clause (i.e., **Clause 3.17.6.1.3**). No positive tolerance on no-load loss, load loss and auxiliary losses as well as total losses will be allowed. Any change in the figures assigned for transformer losses will not be permitted after opening of bids and evaluation will be carried out on the basis of information made available at the time of bid opening. Bid with higher losses as that of provided in the Technical Data Sheet, bid will be treated as non-responsive.

**3.17.6.1.2** The capitalization of power/auto transformer losses shall be as per formula given **in SECTION AA of CBIP Manual on Transformers, 2013 (Publication No. 317).** The calculation results should be submitted to AEGCL for final approval.
The loss figures (both guaranteed & test) for the purpose of this clause shall be at rated frequency and voltage and at principal tap and 75º C. As per Clause No. 3.17.6.1.3, the maximum losses for transformer are fixed, therefore, this clause is not applicable.

**3.17.6.1.3 Maximum losses:**
While the bidders may offer their own design, the maximum limit of losses which include tolerance, but **Standard Fixed Losses for Transformers and Shunt Reactors as per Central Electricity Authority (CEA) letter CEA/PSE&TD/218/3056-4028 dated 01.03.19** shall be as below:

| Sr. No | Rating (MVA) | Voltage Rating (kV) | Phase | No Load Loss (kW) | Load Loss (kW) | $I^2R$ (kW) | Stray + Eddy (kW) | Aux. Loss |
|---|---|---|---|---|---|---|---|---|
| 1. | 200 | 220/132/33 | 3- Phase | AT 35 | 260 | 190 | 70 | 8 |

**3.17.7. Transportation**

**3.17.7.1.1** The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site.

**3.17.7.1.2** The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of transformer and based on route survey; any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the contractor.

**3.17.7.1.3**The inland transportation of the Transformer shall be on trailers equipped with GPS system for tracking the location of transformer at all times during transportation from manufacturer works to designated site. Contractor shall monitor / track the location of the trailer on regular basis and also provide tracking details to respective site/employer at the time of dispatch of Transformer from factory to designated site. Requirement of Hydraulic trailer is envisaged for a load of more than 40 T.

**3.17.7.1.4** All metal blanking plates and covers which are specifically required to transport and storage of the transformer shall be considered part of the transformer and handed over to the Purchaser after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

**3.17.7.1.5**The Contractor shall dispatch the transformer filled with dry air/N2 at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air/N2 during transit and storage till completion of oil filling during erection. A dry air/N2 pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. Generally, the duration of the storage of transformer at site with dry air/N2, shall preferably be limited to three months, after which the Transformer shall be processed as per the recommendation of manufacturer if not filled with oil. The dry air/N2 cylinder(s) provided to maintain positive pressure can be taken back by the contractor after oil filling.
In case turret, having insulation assembly, is transported separately then positive dry air/N2 pressure shall be ensured.

**3.17.7.1.6**The Transformer shall also be fitted with at least 2 numbers of **electronic impact recorders** (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and

handling in all three directions, shall not exceed “3g” for 50mSec (20Hz) or as per contractor standard, whichever is lower.

**3.17.7.1.7**Vendor/EPC shall remove the electronic impact recorders after reaching the Transformer main foundation Location in front of AEGCL representative. Transformer manufacturer/EPC shall stop the electronic impact recorders and soft copy shall be handed over to AEGCL Site representative. EPC/Vendor shall return the electronic impact recorders to Manufacture factory, this hardcopies of report with the values (softcopy shall also be downloadable at site) to be submitted by Vendor at AEGCL Design cell/ Project Team.

**3.17.8.0 Performance**

**3.17.8.1.0** The transformers shall be used for bi-directional flow of rated power. The major technical parameters of three phase transformer units are defined at **Annexure – A.**

**3.17.8.1.1**Transformers shall be capable of operating under natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially ONAF up to specified load and then as OFAF (or ODAF as specified). Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140 deg C. If the Transformer is fitted with two coolers, each capable of dissipating 50 per cent of the loss at continuous maximum rating, it shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler without the calculated winding hot spot temperature exceeding 140 deg C at continuous max rating. The contractor shall submit supporting calculations for the above and the same shall be reviewed during design review.

**3.17.8.1.2**The transformer shall be free from any Electrostatic Charging Tendency (ECT) under all operating conditions and maximum oil velocity shall be such that it does not lead to static discharges inside the transformer while all coolers are in operation.

**3.17.8.1.3** The transformers shall be capable of being continuously operated at the rated MVA without danger, at any tapping with voltage variation of +/-10% corresponding to the voltage of that tapping.

**3.17.8.1.4** The transformers shall be capable of being over loaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

**3.17.8.1.5** Tank hotspot shall not exceed 130 Deg. Celsius. Maximum ambient temperature shall be considered as 50 Deg. C.

**3.17.8.1.6** The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 secs. The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

400kV system – 63 kA for 1sec (sym, rms, 3 phase fault)
220kV system - 50 kA for 1sec (sym, rms, 3 phase fault)
132kV system - 40 kA for 1sec (sym, rms, 3 phase fault)
33kV system – 31.5 kA for 1 sec (sym, rms, 3 phase fault)

However, for transformer design purpose, the through fault current shall be considered limited by the transformer self-impedance only (i.e., Zs = 0).

**3.17.8.1.7** Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any terminals. Mechanical strength of the transformer shall be such that it can withstand 3-phase and 1- phase through fault for transformer rated voltage applied to HV and / or IV terminals of transformer.

The short circuit shall alternatively be considered to be applied to each of the HV, IV and tertiary (LV) transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered. The maximum short circuit output current at the tertiary terminals shall be limited to a safe value to make the transformer short circuit proof. The transformer shall be designed to withstand for short circuit duration of 2 seconds for Thermal stress and the same shall be verified during design review.

**3.17.8.1.8** The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 % continuous over-voltage condition it does not exceed 1.9 Tesla at all tap positions.

**3.17.8.1.9** Transformers shall withstand without damage, heating due to the combined voltage and frequency fluctuations which produce the following over fluxing conditions:

110 % for continuous
125 % for 1 minute
140 % for 5 seconds

Withstand time for 150% & 170% over fluxing condition shall be indicated. Over fluxing characteristics up to 170 % shall be submitted.

**3.17.8.1.10** The air core reactance of HV winding of transformer shall not be less than 20% for400kV class Transformer.

**3.17.9.0 Tertiary Windings (if applicable as per Annexure - A)**

**3.17.9.1.0**The tertiary windings shall be suitable for connection of reactors or capacitors which would be subjected to frequent switching and shall be suitable for connection to LT Transformer for auxiliary supply. All the windings shall be capable of withstanding the stresses which may be caused by such switching. The tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals and for 1/3rd of the MVA capacity of the transformer although the cooling for continuous thermal rating of the tertiary winding shall be for 5MVA capacity. Tertiary, if not loaded, i.e., not connected to reactor, capacitor or LT transformer etc., its terminals shall be insulated to avoid any accidental short circuiting.

If required, the surge arrester (with polymer housing) shall be provided externally in proximity with bushings mounted suitably on the transformer tank. Alternatively, if required, the surge arrester may be mounted internally (as per standard practice of manufacturer), in order to limit the transfer surge within the BIL specified. Further, in case external surge arresters are required, same shall be mounted on Transformer tank.

**3.17.10.0 Radio Interference and Noise Level**

**3.17.10.1.0** The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimise interference with communication circuit.

**3.17.10.1.1** The noise level of transformer, when energised at normal voltage and frequency with fans and pumps running shall not exceed the values specified at **Annexure - A**, when measured under standard conditions.

**3.17.11.0 Measurable Defects**

**3.17.11.1.0** The following shall constitute as Measurable Defects for the purpose of Defect Liabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Transformer and OLTC (including oil migration) either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are as detailed below:

| H2 | CH4 | C2H2 | C2H4 | C2H6 | CO | CO2 | TDCG |
|---|---|---|---|---|---|---|---|
| 100 | 120 | 1 | 50 | 65 | 350 | 2500 | 720 |

c) The winding tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable for tan delta.

d) The moisture content goes above 12 ppm at any temperature during operation including full load.

**3.17.12.0 Design review**

**3.17.12.1.0** The transformer shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. The manufacturer will be required to demonstrate the adequate safety margin w.r.t thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of transformer with least maintenance and to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at **Annexure – B**.

**3.17.12.1.1** Design reviews shall be conducted by Purchaser or an appointed consultant during the procurement process for transformers; however, the entire responsibility of design shall be with the manufacturer. Purchaser may also visit the manufacturer's works to inspect design, manufacturing and test facilities at any time.

**3.17.12.1.2** The design review will commence after placement of award and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under the scope. It shall be conducted generally following the "CIGRE TB 529: Guidelines for conducting design reviews for power transformers".

**3.17.12.1.3** The manufacturer shall provide all necessary information and calculations to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IEC or Cigre SC 12 shall be applied for short circuits withstand evaluation.

**3.17.12.1.4 Type test requirement & its validity**

The offered transformer or the transformer, the design of which is similar to the offered transformer, should have been successfully type tested as per ***clause 3.17.4.0. Specific Requirement***. Manufacturer may use same or different approved make of Bushings and other accessories used in type tested or short circuit tested unit in their transformer. Further, type test report of transformer shall only be acceptable provided the offered transformer has been manufactured from the same plant. Central Electricity Authority's "Guidelines for the validity period of type tests conducted on major electrical equipment in power transmission system" shall be followed regarding the validity of type tests of Bushings and other accessories.

**"CRITERIA FOR SELECTION OF SIMILAR REFERENCE TRANSFORMER FOR DYNAMIC SHORT CIRCUIT WITHSTAND TEST" shall be as per CEA's 'Standard Specifications and technical Parameters for Transformers and Reactors (66 kV & above voltage class)' vide letter no. 'File No.CEA-PS-14-169/2/2019-PSETD Division' dated April, 2021 and CEA's notification no. CEA-TH-17/1/2021-TETD Division—dated 23rd December, 2022.**

**3.17.13.0 Construction Details**

The construction details and features of transformer shall be in accordance with the requirement stated hereunder.

**3.17.13.1.1 Tank**

**3.17.13.1.1.1** Tank shall be fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062.

**3.17.13.1.1.2** All seams and joints which are not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to BS-5135/IS 9595. After fabrication of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1/IS 10801.

**3.17.13.1.1.3** Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water. The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

**3.17.13.1.1.4** Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete transformer when filled with oil without structural damage to any part of the transformer. The factor of safety at any one point shall not be less than 2.

b. A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the transformer filled with oil allowing in addition to maximum possible misalignment of the jacking force to the centre of the working surface.

c. Suitable haulage holes shall be provided.

d. 04 nos. of Gate valves for UHF sensors for PD Measurements (applicable for 400kV Transformer only) at various locations. Location of valves shall be finalized during design review.

e. Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

**3.17.13.1.1.5** The tank shall be designed in such a way that it can be mounted either on the plinth directly or on rollers, as per manufacturer's standard practice.

**3.17.13.1.1.6**The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without damage when using plates or rails and the base plate shall have following minimum thickness:

| Length of tank (m) | Minimum plate thickness (mm) |
|---|---|
| Flat bases | |
| Over 2.5 m but less than 5m | 20 |
| Over 5 m but less than 7.5m | 26 |
| Over 7.5 m | 32 |

**3.17.13.1.1.7**Tank shall be capable of withstanding, without damage, severe strains that may be induced under normal operating conditions or forces encountered during lifting, jacking and pulling during shipping and handling at site or factory. Tank, tank cover and associated structure should be adequately designed to withstand, without damage or permanent deflection / deformation, the forces arising out of normal oil pressure, test pressures, vacuum, seismic conditions and short circuit forces specified.

**3.17.13.1.1.8**Tank MS plates of thickness >12 mm should undergo Ultrasonic Test (UT) to check lamination defect, internal impurities in line with ASTM 435 & ASTM 577.

**3.17.13.1.1.9** All pipes connected to Transformer shall follow IS 1239.

**3.17.13.1.2 Tank Cover**

**3.17.13.1.2.1** The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the Buchholz relay.

**3.17.13.1.2.2** At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

**3.17.13.1.2.3**The tank cover shall be provided with pockets for OTI, WTI and RTDs including 2 spare pockets. The location of pockets shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

**3.17.13.1.2.4** Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

**3.17.13.1.2.5** To allow for the effect of possible induced and capacitive surge current flow, the tank cover and bushing turret shall be fixed to the transformer in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

**3.17.13.1.2.6** The transformer shall be provided with a suitable diameter pipe flange, butterfly valve, bolted blanking plate and gasket shall be fitted at the highest point of the transformer for maintaining vacuum in the tank.

**3.17.13.1.3 Gas venting**

The transformer cover and generally the internal spaces of the transformer and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the transformer to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer is being mounted.

**3.17.13.1.4 Gasket for tank & cover**

All gasketed joints in contact with oil shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints unless otherwise approved shall be of the O-ring and groove type. All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

All tank gaskets used shall be of NBR (Acrylonitrile butadiene Rubber generally known as NBR) and properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149 (Grade IV) Material selected shall suit temperature conditions expected to be encountered. Neoprene / cork sheets gaskets are not acceptable. The Gaskets and O-rings shall be replaced every time whenever the joints are opened.

**3.17.13.1.6Roller Assembly and Anti Earthquake Clamping Device**

The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track.

Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer. The rail track gauge shall be 1676 mm. 3-Phase auto transformers of 400kV class shall have four (4) rails and other voltage class transformers shall have two (2) rails.

To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

**3.17.13.1.7Conservator**

**3.17.13.1.7.1** Main tank conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts, prismatic oil level gauge and Conservator Protection Relay (CPR)/Air cell puncture detection relay.

Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be installed to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service.

**3.17.13.1.7.2** Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil.

**3.17.13.1.7.3** The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

**3.17.13.1.7.4** Conservator shall be positioned so as not to obstruct any electrical connection to transformer. Preferably, the conservator tank shall be mounted on a separate structure adjacent to transformer tank with ladder arrangement & platform for ease of maintenance.

**3.17.13.1.7.5** The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stenciled on its underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the transformer is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer rating and diagram plate shall bear a warning statement that the **"Main conservator is fitted with an air cell".**

**3.17.13.1.7.6** Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to raise up to 110 deg.C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

**3.17.13.1.7.7** The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, and the recommended replacement intervals.

**3.17.13.1.7.8** The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalising the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

**3.17.13.1.7.9** The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough so that the oil will not generally become saturated with oxygen. Air cells with well proven long-life characteristics shall be preferred. OLTC shall have conventional type conservator (without air cell) with magnetic oil level gauge with potential free oil level alarm contact and prismatic oil level gauge.

**3.17.13.2.0Piping works for conservator**

**3.17.13.2.1** Pipe work connections shall be of adequate size preferably short and direct. Only radiused elbows shall be used.

**3.17.13.2.2** The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be loaded straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay.

**3.17.13.2.3**This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees. The feed pipe diameter for the main conservator shall be not less than 80mm.

**3.17.13.2.4** A double flange valve of preferably 50 mm and 25 mm size shall be provided to fully drain the oil from the main tank conservator and OLTC conservator tank respectively.

**3.17.13.2.5** Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

**3.17.13.3.0 Dehydrating Silica gel Filter Breather**

**3.17.13.3.1**Conservator of Main Tank and OLTC shall be fitted with a dehydrating silica gel filter breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such that:

a) Passage of air is through silica gel.
b) Silica gel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in colour of the crystals.
d) Breather is mounted approximately 1200 mm above rail top level.
e) To minimise the ingress of moisture three breathers (of identical size) for 220kV and above voltage class transformer and two breathers (of identical size) for below 220kV class transformer shall be connected in series for main tank conservator. Manufacturer shall provide flexible connection pipes to be used during replacement of any silica gel breather.
f) To minimise the ingress of moisture, two in series of identical size shall be connected to OLTC Conservator. Contractor shall provide flexible connection pipes to be used during replacement of any silica gel breather.

**3.17.13.3.2 Thermosyphon Filter:**

**To extract the harmful constituents like water, acids etc. from oil, Thermosyphon filter of cylindrical shape with perforated steel trays filled with absorbents such as active alumina should be provided.**

The filter assembly shall be mounted on the transformer as well as ground supported and connected with pipes and shut off valves. Suitable instructions required to be followed for commissioning, dismantlement and maintenance of filter arrangement, re-generation and storage of the absorbent etc. must be included in the instrumentation manual. A detailed drawing showing internal arrangement shall be submitted.

The oil & absorbent capacity required in the thermo-syphon filter is as under.

i) Quantity of oil - 1.0% of total oil by weight
ii) Quantity of absorbent - 0.2% to 0.25% of total oil by weight

**3.17.13.4.0Pressure Relief Device**

**3.17.13.4.1**One PRD of 150 mm Diameter is required for every 30000 Litres of oil. However, at least two numbers PRDs shall be provided. Its mounting should be either in vertical or horizontal orientation, preferably close to

bushing turret or cover. PRD operating pressure selected shall be verified during design review. PRD shall be provided with special shroud to direct the hot oil in case of fault condition. It shall be provided with an outlet pipe which shall be taken right up to the soak pit of the transformer. The size (Diameter) of shroud shall be such that it should not restrict rapid release of any pressure that may be generated in the tank, which may result in damage to equipment. Oil shroud should be kept away from control cubicle and clear of any operating position to avoid injury to personnel in the event of PRD operation. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa.

It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. Suitable canopy shall be provided to prevent ingress of rain water. One set of potential free contacts (with plug & socket type arrangement) per device shall be provided for tripping. Following routine tests shall be conducted on PRD:

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

**3.17.13.5.0Sudden Pressure Relay**

**3.17.13.5.1** One number of Sudden Pressure relay with alarm/trip contacts **(Terminal connection plug & socket type arrangement**) shall be provided on tank of transformer. Operating features and size shall be reviewed during design review. Suitable canopy shall be provided to prevent ingress of rain water. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay

**3.17.13.6.0 Buchholz Relay**

**3.17.13.6.1** Two numbers double float, reed type Buchholz relay shall be provided in series of the connecting pipe between the oil conservator and the Transformer tank with minimum distance of five times pipe diameters between them. Any gas evolved in the Transformer shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Transformer in service. Suitable canopy shall be provided to prevent ingress of rain water. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement),** one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

**3.17.13.6.2** The Buchholz relay shall not operate during starting/ stopping of the transformer oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the transformer during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

**3.17.13.7.0 Oil Surge Relay**

Reed type Oil Surge Relay shall be provided individually to each tap changer diverter switches and one common OSR at OLTC conservator tank. Valves of required size are to be put before and after of each OSR. For 3-phase OLTC, there shall be two numbers OSR. It is preferable that each oil surge relays have independent indicators. OSR shall have two trip contacts.

**3.17.13.8.0 Oil Temperature Indicator (OTI)**

All transformers shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication with angular sweep of 270°. It shall have adjustable, potential free alarm and trip contacts besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI instrument by means of flexible capillary tubing with stainless-steel armoured. Temperature indicator dials shall have linear gradations to clearly read at least every

2 deg C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full-scale deflection. The setting of alarm and tripping contacts shall be adjustable at site. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947/IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

**Temperature transducer with Pt100 sensor (As per ANNEXURE- J)**
RTD shall be provided with PT100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The PT100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The PT100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil for OTI system and shall provide dual output 4-20mA for SCADA system. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between PT100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC panel / BCU for further transfer data to SCADA through IEC 61850 compliant communications.

**3.17.13.9.0 Winding Temperature Indicator (WTI)**
**3.17.13.9.1**All Transformers shall be provided with a device for measuring the hot spot temperature of each winding (HV, IV and LV) with dial type thermometer of 150 mm diameter for winding temperature indication with angular sweep of 270° and shall have adjustable potential free alarm and trip contacts besides that required for control of cooling equipment if any. The setting of alarm and tripping contacts shall be adjustable at site. A temperature sensing bulb located in a thermometer pocket on tank cover should be provided to sense top oil. This shall be connected to the WTI instrument by means of flexible capillary tubing with stainless-steel armoured. WTI shall have image coil and auxiliary CTs, if required to match the image coil, shall be mounted in the Marshalling Box / cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2°C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full-scale deflection. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947 /IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

**Temperature transducer with Pt100 sensor for each winding (As per ANNEXURE- J)**
RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC / BCU panel for further transfer data to SCADA through IEC 61850 compliant communications.

The temperature indicators (OTI & WTI) shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

**3.17.13.10.3 Optical sensors & temperature measuring unit**
**3.17.13.10.3.1** Optical temperature sensors shall be fitted on each Transformer unit. 16 number probes for 3-ph unit shall be provided. The optical sensors measuring system shall be of direct measurement non-calibrating

type. All the sensors shall be brought out to separate optical sensor box or in Individual Marshalling Box mounted on transformer tank to facilitate measurement of temperature during service life on each unit.

**3.17.13.10.3.2** In order to facilitate measurement of temperature from the optical sensors, temperature measuring unit/system having at least 16 channels shall be mounted inside the separate optical sensor box or Transformer Marshalling Box for each transformer unit**.** The measuring unit shall be capable to retain temperature data for at least 30 days with facility to download these data.

**3.17.13.10.3.3** Temperature measuring unit/system shall be suitable for satisfactory operation with ambient conditions and IEC 61850 compliant to interface with Employer's SCADA system through FO port.

**3.17.13.10.3.4** Location of optical temperature sensors inside the transformer shall be decided during design review.

**3.17.13.10.3.5** The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

**3.17.13.10.4 Earthing Terminals**

**3.17.13.10.4.1** Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

**3.17.13.10.4.2** Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each cooler, individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/ Optical Sensor Box etc. double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper links.

**3.17.13.10.4.3** Equipotential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc. connected to tank shall also be provided with equipotential flexible copper link.

**3.17.13.10.4.4**Each transformer unit should have provision for earthing and connected to grounding mat when not in service. For this purpose, all line Terminals shall also be earthed through neutral by flexible copper connection. Contractor shall provide suitable arrangement for the above. 1.1kV Grade PVC FR type cable of 16 sq.mm (minimum) shall be used for above connection. Neutral shall have provision for connection to ground by a brass/tinned copper grounding bar supported from the tank by using porcelain insulator. The end of the tinned/brass copper bar shall be brought to the bottom of the tank at a convenient point for making bolted connection to 75 X 12 mm GS flat connected to station grounding mat. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper.

**3.17.13.11.0 Core**

**3.17.13.11.1** The magnetic circuit shall be core type. Each limb shall be joined with top and bottom yokes. The laminations shall be made from high grade non-ageing cold rolled grain oriented (CRGO) silicon alloy of **HI -B** grade steel (as per **BIS / IEC**). Indian transformer manufacturers shall use core material as per above specification with BIS certification. Only those bidders who directly imported **CRGO** either from the manufacturer or through their accredited marketing organization of repute (and not through any agent) shall be considered. **In support of this requirement the bidder shall submit an undertaking in specified format (Annexure C) in the form of affidavit on Rs.100/- stamp paper, duly notarized.**

Laminations of one particular thickness i.e., 0.23mm or 0.27mm or better (quoted grade and type) shall be used. Laminations of different grade(s) and different thickness(s) are not allowed to be used in any manner or under any circumstance.

**3.17.13.11.2 The CRGO shall be cut at Mill's authorized Processing unit only.**

**3.17.13.11.3**The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under 10% over voltage and maximum ambient air temperature conditions of 50 deg C. Adequate temperature margin shall be provided to maintain the long-life expectancy for this material.

The hot spot temperature and surface temperatures in the core shall be calculated for over voltage conditions specified in the document and it shall not exceed 125 deg C and 120 deg C respectively.

**3.17.13.11.4**Core and winding shall be capable of withstanding the shock during transport, installation and service and adequate provision shall be made to prevent movement of core and winding with respect to tank during these conditions.

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

**3.17.13.11.6** Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

**3.17.13.11.7**The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

**3.17.13.11.8**Adequate lifting lugs will be provided to enable the core and windings to be lifted.

**3.17.13.11.9**Single point core earthing should be ensured to avoid circulating current. Core earth should be brought separately on the top of the tank to facilitate testing after installation on all transformers. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp'. Cross section of Core earthing connection shall be of minimum size 80 sq.mm copper with exception of the connections inserted between laminations which may be reduced to a cross-sectional area of 20 sq. mm tinned copper where they are clamped between the laminations.

**3.17.13.11.10** In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

**3.17.13.11.11**The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2.5 kV (DC) for 1 minute. Insulation resistance shall be minimum 500MΩ for all cases mentioned above.

**3.17.13.11.12** The maximum flux density in any part of the core and yoke at the rated MVA, voltage & frequency shall be such that less than 10% continuous over voltage condition does not exceed 1.9 Tesla.

**3.17.13.11.13** For consideration of over fluxing, the transformer shall be suitable for continuous operation for values of over fluxing at (i) 110% (ii) one minute for 125% and (iii) 5 seconds for 140% of rated voltage.

**3.17.13.11.14** The Transformer shall be of **BOLTLESS** core design. The Bidders will furnish documentary evidence with proof of their experience and performance in such type of design.

**3.17.13.11.15** When bell type construction is offered, suitable projecting guides shall be provided on core assembly to facilitate removal of tank. The supporting framework of core shall be so designed so as to avoid

presence of pockets, which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.

**3.17.13.11.16** Successful Bidder shall furnish calculation towards maximum peak value of magnetizing in- rush current and shall justify that the transformer will not trip due to this during initial charging and subsequent charging.

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

**3.17.13.11.18** The prime core materials are only to be used. Bidders should furnish following document as applicable as a proof towards use of prime Core material to be submitted before the stage inspection:

(a) Invoice of supplier
(b) Mill's test certificate
(c) Packing List
(d) Bill of lading
(e) Bill of entry certificate by Custom.
(f) Description of material, electrical analysis, physical inspection, certificate for surface defects, thickness and width of the materials.
(g) Place of cutting of core materials

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

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

**3.17.14.0 Windings**

**3.17.14.1.0 General**

- The manufacturer shall ensure that windings of all transformers are made in clean, dust proof (Clean room class ISO 9 or better as per ISO 14644-1), humidity-controlled environment with positive atmospheric pressure. The conductors shall be of electrolytic grade copper free from scales and burrs. Oxygen content shall be as per IS 12444.
- Epoxy bonded Continuously Transposed Conductor (CTC) shall be used in main winding for rated current of 400 A or more.
- The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non-catalytic and chemically inactive in transformer oil during service.
- Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.
- The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.
- The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.
- The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and considering the fact that the system will not always be in the new factory condition.

- The barrier insulation including spacers shall be made from high density pre compressed pressboard (1.15 gm/cc minimum for load bearing and 0.95 gm/cc minimum for non-load bearing) to minimize dimensional changes. Kraft insulating paper used on conductor should have density of >0.75 g/cc.
- The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.
- Wherever required, electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit.
- All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped.
- Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding. Either brazing/crimping type of connections are permitted for joints. It shall be time proven and safely withstand the cumulative effect of stress which may occur during handling, transportation, installation and service including line to line and line to ground faults /Short circuits. Manufacturer shall have system which allows only qualified personnel to make brazing or crimping joints.
- Winding paper moisture shall be less than 0.5%.
- **In the case of ICT switch tertiary**, the insulation of LV (Tertiary) winding shall be adequate to withstand surge voltages appearing across them as a result of transfer due to impulse striking on HV or IV terminals. **The transformer shall be suitably designed so that the surges transferred to tertiary winding do not exceed the permissible limits** without the use of any external means such as surge capacitors etc. under any condition. The tenderer shall also state whether the transferred surges could be restricted to 170KVP without the use of any external means. **The current density of the conductor used for tertiary windingshallnotexceedthecurrentdensityspecifiedforthemainwinding**/conductor.
- The stacks of windings shall receive adequate shrinkage treatment before and after final assembly. Adjustable devices, if necessary, shall be provided for taking up possible shrinkage of coils if any, in service. The provision made in this respect shall be clearly brought out in the Bid.
- **The conductors shall be transposed at suitable intervals in order to minimize eddy current** and to equalize the distribution of current and temperature along the windings.
- The transformer manufacturer should have in house availability of vapour phase Drying (VPD) plant for proper drying of the insulation. In case VPD facility is not available, the bidder will prove that the method of drying adopted by them is equivalent or better than VPD in terms of level of dryness and other benefits of VPD.

**3.17.14.1.1 Bracing of Windings**

- The windings and connections of all transformers shall be braced to withstand socks, which may occur during transport or due to switching and other transient conditions during service.
- The winding shall be clamped securely in place, so that they will not be displaced or deformed during short circuit. The assembled core and winding shall vacuum dried and suitably impregnated before removing from the treating tank.
- Coil clamping rings, if provided shall be of steel.
- If the transpose winding is built up of section of disc coils, separated by spacers, the clamping arrangements shall be such that equal pressures are applied to all columns of spacers. All such spacers shall be securely located, shall be of suitable material and shall receive adequate shrinkage treatment before assembly.
- 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.
- 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.
- 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.
- Winding and connections shall be braced to withstand shocks during transport or short circuit.

- 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.
- Terminals of all windings shall be brought out of the tank through bushings for external connections.
- The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the winding can be made readily without special equipment. The coils shall have high dielectric strength.
- 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.
- Adequate barriers shall be provided between coils and core and between high and low voltage coil. End turns shall have additional protection against abnormal line disturbances. The TM is to submit the process at the time of the bid.
- Tappings 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 the transformer at all voltage ratios.
- Magnitude of impulse surges transferred from HV to LV windings by induction and capacitance coupling shall be limited to B.I.L. of LV winding.

**3.17.14.1.2 Current carrying connections**

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

**3.17.14.1.3 Winding terminations into bushings**

- Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the transformer in service.
- The winding end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.
- Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.
- In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.
- Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

**3.17.15.0 Transformer Loading**

- The limits of temperature rise are given in general technical parameters.
- The transformer shall be capable of remaining in operation at full load without the measured winding hot spot temperature exceeding 150°C for:

    - 10 minutes with complete (i.e., 100%) failure of cooler system.
    - 20 minutes with 50% of cooler system in service.

- The permissible temperature of the top oil shall refer to the specific loading combination for which the total losses are the highest. Individual permissible winding temperature rise shall be considered relative to the specified loading combination which is the most severe for the particular winding under consideration.

**3.17.16.0 Terminal Arrangement**

Specific requirement of bushings and their ratings etc. are as per general technical parameters.

**3.17.17.0 Bushings**

- The electrical and mechanical characteristics of bushings shall be in accordance with IS: 2099 and IS: 3347 (Part-III/Section-I). Dimensions and requirements of condenser bushings shall be in accordance with IS 12676, 1989.
- Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare. Transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.
- 420kV, 245kV, 145kV and 52kV Bushings shall be either of the following type:
  i. RIP (Resin Impregnated paper) condenser type with composite polymer insulator (housing)
  ii. Or RIS (Resin Impregnated Synthetic) condenser type with composite polymer insulator (housing).

  However, OIP (Oil impregnated Paper) with porcelain / composite polymer housing type is also acceptable for 52kV Bushings.

a) 36kV and below voltage class bushing shall be solid or oil communicating type with porcelain housing.

b) No arcing horns shall be provided on any bushing.

c) Condenser type bushings shall be provided with-

   i. Oil level gauge.
   ii. Oil filling plug and drain valve if not hermetically sealed;
   iii. Tap for capacitance/tan delta measurement.

d) RIP/RIS type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

e) Where turret type current transformers are specified, the bushings shall be removable without disturbing the current transformers.

f) Bushing for voltage of 52 kV and above shall be RIP/RIS bushing with composite polymer insulator. 36 kV and below voltage class bushing shall be solid porcelain or oil communicating type.

g) No arcing horns shall be provided on the bushings. Bushing shall be as per technical particulars furnished. Bushings of identical rating shall be interchangeable to optimise the requirement of spares.

h) RIP/RIS Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

i) The terminal marking and their physical position shall be as per IEC: 60076.

j) Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP) at Transformer manufacturing works as routine test before dispatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

k) Tan δ value of RIP / RIS condenser bushing shall be 0.005 (max.) in the temperature range of 20°C to 90°C. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results (measured at approx. similar temperature conditions) during warrantee period. Tan delta value of OIP Bushing shall be 0.004 (Max) measured at ambient temperature. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results during warrantee period.

l) Special precaution shall be taken to eliminate moisture from paper insulation during manufacture, assembly, transport and erection.

m) Bushing turrets shall be provided with vent pipes which shall be connected to route any gas collection through the Buchholz relay.

n) To accommodate the bushing current transformers, space provided on the various voltage class bushings shall be as under:

420kV: 400 mm *

245kV: 300 mm *
: 600 mm **

145kV: 100 mm *
: 300 mm **
: 600 mm ***

**Note:**
*** = for one BCT**
**** = For two BCTs**
***** = For three BCTs**

**3.17.17.1.0 Terminal Connectors**

- Bushing terminals shall be provided with terminal connectors of approved type and size for connection to external parts. Terminal connectors should have been successfully type tested strictly as per IS:5561.
- **All connections with ACSR/AAAC conductors shall be Nut and bolt type.**
- Connectors shall be of **electrolytic grade copper forged and silver plated/tinned.** No part of a clamp shall be less than 10 mm thick.
- Non-magnetic stainless-steel nuts, bolts and plain washers shall be used. Nuts and bolts shall have hexagonal head with threads as per IS and shall be fully threaded type. Instead of spring washers, check/lock nuts shall be provided.
- The connectors shall be designed for minimum 120% of the maximum current carrying capacity of the ACSR conductor and the temperature rise under these conditions shall not be more than 50% of that of the main conductor.

**3.17.17.2.0 Bushing current transformers**

- Current transformers shall comply with IS:2705.
- It shall be possible to remove turret mounted CTs from the transformer tank without removing the tank cover. Necessary precaution shall be taken to minimize the eddy currents and local heat

generated in the turret.

- All secondary leads shall be brought to a terminal box near each bushing. These terminals shall be wired up to the Cooler Control Cabinet using separate cables for each core/phase.
- BushingCTparametersindicatedinthespecificationaretentativeandliable to change within reasonable limits. The Bidder shall obtain the Purchaser's approval before proceeding with design of Bushing CTs.

**3.17.17.3.0 Terminal Marking**

The terminal marking and their physical position shall be in accordance with IS: 2026 unless otherwise specified**.**

**3.17.17.4.0 Neutral Formation and Earthing Arrangement**

The neutral of the transformer shall be brought out through bushing. The neutral terminal of 3-phase transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanised steel flats connected to Employer's grounding mat.

**3.17.18.0 Cooling Equipment and its Control**

**3.17.18.1.0 Cooling Equipment for Radiator Bank**

- The cooler shall be designed using radiator banks or tank mounted radiators. Design of cooling system shall satisfy the performance requirements.
- In case of separately mounted radiator bank arrangement, the main tank shall have provision such that cooler banks can be placed on either side of the main tank without the need of any extra member/pipe maintaining the electrical clearances.
- The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1.2 mm. Each radiator bank shall be provided with the following accessories:
    - Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
    - Top and bottom shut off valve
    - Drain Valve and sampling valve
    - Top and bottom oil filling valves
    - Air release plug
    - Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanised Steel flats.
    - Thermometer pockets with captive screw caps at cooler inlet and outlet.
    - Lifting lugs: Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection.
- If radiators are directly mounted on tank, sufficient number of thermometer pockets fitted with captive screw cap on the inlet and outlet of tank side pipe of radiators shall be provided to record temperature during temperature rise test.
- One number standby fan shall be provided with each radiator bank.
- Cooling fans shall not be directly mounted on radiator. It may cause undue vibration. These shall be located so as to prevent ingress of rain water. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.
- Two (2), 100% centrifugal or axial in line oil pumps, if applicable, (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be taken to prevent mal-operation of Buchholz

relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

- An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication in the flow indicator and potential free contacts for remote alarm shall be provided.
- Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.
- Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall be of premium efficiency class IE3 conforming to IS: 12615. Each cooling fan and oil pump motors shall be provided with starter, thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55 as per IS/IEC 60034-5.
- The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.
- Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

**3.17.18.1.1 Cooling Equipment Control for Radiator banks**

- Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The Contractor shall recommend the setting of WTI for automatic changeover of cooler control over entire cooling option. The setting shall be such that hunting i.e., frequent start-up operations for small temperature differential do not occur.
- Suitable manual control facility for cooler fans and oil pumps shall be provided. Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans and pump manually. The changeover to standby oil pump in case of failure of service oil pump shall be automatic.
- In addition to the traditional starting of fan and pump by winding & oil temperature, the starting of forced cooling shall be done if the load exceeds a current setting of 0.6 p.u. for 5 seconds. Furthermore, a one-week timer is required to check the healthiness of the cooling system on a routine basis for one hour at a time.
- Following lamp indications shall be provided in cooler control cabinet:
    - Cooler Supply failure (main)
    - Cooler supply changeover
    - Cooler Supply failure (standby)
    - Control Supply failure
    - Cooling fan failure for each bank
    - Cooling pump failure for each pump
    - Common thermal overload trip
- One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet.
- The cooler control cabinet / Individual Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired up to the terminal board in the cooler control cabinet/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.
- All the necessary terminations for remote connection to Purchaser's panel shall be wired up to the Marshalling Box.
- The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder. In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

**3.17.19.0 Paint system and procedures**

The typical painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure –D**. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C. The detailed painting procedure shall be finalized during award of the contract.

**3.17.20.0 Insulating Oil**

a) The required transformer oil shall be in the scope of transformer manufacturer.
b) The supplier shall dispatch the transformer filled with Nitrogen. The Bidder shall take care of the weight limitation on transport and handling facility at site. Necessary arrangement shall be ensured by the supplier to take care of pressure drop of nitrogen during transit and storage till completion of oil filling during erection. A gas pressure-testing valve with necessary pressure gauge and adapter valve shall be provided.
c) The quality of the oil supplied with transformer shall conform to the oil parameters specified in this clause.
d) No inhibitors shall be used in the oil.
e) The oil samples will be drawn as follows:
    i. Prior to filling
    ii. Before and after heat run test
    iii. Before energizing

    All tests as per IEC: 60296 shall be conducted on all samples.
f) The insulating oil shall be subjected to testing in the oil manufacturer's works, before supply, in the presence of the representative of AEGCL and the representative of the transformer manufacturer.
g) Sufficient quantity of oil necessary for first filling of all tanks, coolers and radiators at the proper level along with 10% extra oil by weight for topping up shall be supplied in non-returnable containers suitable for outdoor storage.
h) The Bidder shall warranty that characteristic of oil furnished shall comply with the requirements specified in IEC: 60296 with the latest amendment /revision and shall be suitable for EHV grade transformers.

**(Note: The colour of the barrels in which Naphthenic based transformer oil is to be supplied shall be Red)**
Insulating oil shall be virgin high grade inhibited, conforming to IS 335 / IEC-60296 & all parameters specified at **Annexure – E**, while tested at oil supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at **Annexure – E**, prior to dispatch of oil from refinery to site. The Unused Inhibited Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, and oil after filtration and settling are attached at **Annexure – E**. The oil test results shall form part of equipment test report. Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.
Oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil which shall be supplied at site and shall meet parameters as per specification.

**3.17.20.1.0 Particles in the oil**

The particle analysis shall be carried out in an oil sample taken before carrying out FAT at manufacturer's works and after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength". Particle limit as shown below shall be ensured by manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8. After filtration the oil is to be flushed and particle count to be measured.

Limiting value for the particle counts are 1000 particle/100 ml with size ≥ 5 µm; 130 particle/100 ml with size ≥ 15 µm.

**3.17.20.1.1 Oil filling**

- Procedures for site drying, oil purification, oil filling etc. shall be done as per EMPLOYER Field Quality Plan (FQP).

- The duration of the vacuum treatment shall be demonstrated as adequate by means of water / dew point measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.
- Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Transformer is oil filled up to the Buchholz relays.
- The minimum safe level of oil filling (if different from the Buchholz level) to which the Transformer shall be oil filled under vacuum, shall be indicated in the manual.
- The Ultra High Vacuum type oil treatment plant (on returnable basis) of adequate capacity (**generally 6000** litres per hour and above) suitable for treatment of oil in EHV class Transformer shall be used. The plant shall be capable of treatment of new oil (as per IEC 60296) and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow:
  i. Removal of moisture from 100 ppm to 3 ppm (max.)
  ii. Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
  iii. Improvement of dielectric strength break down voltage from 20 to 70 KV
  iv. Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
  v. Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.
  vi. Processing temperature shall be automatically controlled and have an adjustable range from 40 deg C to 80 deg C.
- The above oil treatment plant (Filtration unit) shall be arranged by the bidder at his own cost.

**3.17.20.2.0 Transportation of Oil**

The insulating oil for the Transformer shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer, in view of risk involved in balk storage, pilferage and fire hazard. In case this oil is not filled in Transformer due to delay in commissioning, same oil shall be used only after testing and ensuring that oil parameters are well within the specified limits.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilisation of oil but in any case, before contract closing. However, the spare oil shall be delivered in non-returnable drums.

**3.17.21.0 Valves**

- All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.
- Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.
- Each valve shall be provided with the indicator to show clearly the position (open/close) of the valve.
- All valves flanges shall have machined faces. Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.
- All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.
- The oil sampling point for main tank shall have two identical valves put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.
- Valves or other suitable means shall be provided to fix various on-line condition monitoring systems to facilitate continuous monitoring.
- Gland packing/gasket material shall be of “O” ring of nitrile rubber for all the valve’s flanges. All the flanges shall be machined.
- Type of valves shall be used for transformer as per following table. The location, size of valves for other application shall be finalised during design review.

| Sl. No. | Description of Valve | Type |
|---|---|---|
| 1 | Drain Valve | Gate |
| 2 | Filter valve | Gate |
| 3 | Sampling Valve | Globe |
| 4 | Radiator isolation valve | Butterfly |
| 5 | Buchholz relay isolation valve | Gate |
| 6 | Sudden pressure relay | Gate |
| 7 | OLTC- tank equalizing valve | Gate /Needle |
| 8 | OLTC Drain cum filling valve | Gate |
| 9 | Valve for vacuum application on Tank | Gate |
| 10 | Conservator Drain valve | Gate |
| 11 | Aircell equalizing valve | Gate/ Globe/Ball |
| 12 | Valve for Conservator vacuum (top) | Gate |
| 13 | Filter valve for Cooler Bank (Header) | Gate |
| 14 | Cooler Bank isolation valve | Butterfly |
| 15 | Pump Isolation valve | Butterfly |
| 16 | Valve for N2 injection (NIFPS) | Gate |
| 17 | Valve for NIFPS Drain | Gate |
| 18 | Valve for UHF Sensors | Gate |

- Flow sensitive conservator Isolation valve:
    a) In order to restrict the supply of oil in case of a fire in transformer, flow sensitive valve shall be provided to isolate the conservator oil from the main tank. The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. It shall not operate when oil pumps are switched on or off. This valve shall be located in the piping between the conservator and the Buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.
    b) When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset. All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.
- All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.
- All hardware used shall be hot dip galvanised/stainless steel.

**3.17.21.1 Cabling**

**3.17.21.1.1**Buchholz Relay, Magnetic Oil Level Gauge, Pressure Relief Device & Sudden pressure relay to be wired through unarmoured cable of 1.5 sq.mm (minimum), inside GI conduit, with no part exposed. Cable shall be protected by flexible stainless-steel pipe, at both ends as per requirement. Proper sealing arrangement to be provided at both ends to avoid ingress of water.

The cross section of “control cable” shall be 1.5 sq.mm (minimum) except for CT circuits which should be 2.5 sq.mm (minimum).

All other cables shall be armoured type and shall be routed through covered cable tray or GI conduit and shall be properly dressed.

Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at **Annexure-M** Contractor shall provide type tested cables from approved sources. No type testing for cables is envisaged. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc. as required shall be considered included in the scope of supply.
Cabling of spare unit with isolator switching arrangement shall be in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall be brought in common marshalling box of all the banks. From CMB all the control, protection and indication signals of R, Y, B and Spare units shall be transferred to Purchaser's Control panels / SCADA. Change-over of spare unit signals with faulty unit shall be done through Purchaser's C & R panels / SCADA level. Changeover of RTCC signals shall be carried out in CMB.

**3.17.22.0 Tap Changing Equipment**
Each transformer shall be provided with On Load Tap changing equipment as specified elsewhere.

**3.17.22.1.0 ON Load Tap Changing (OLTC) Equipment (Oil type)**
**3.17.22.1.1 Main OLTC Gear Mechanism**
Each three-phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load.

OLTC shall be motor operated suitable for local as well as remote operation. The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment. The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.

Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve of minimum size, accessible from ground, shall be provided to take sample of oil from the OLTC chamber. It shall also be fitted with an oil surge relay which shall be connected between OLTC oil chamber and OLTC conservator tank.

Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

**3.17.22.1.2 Local OLTC Control Cabinet (Drive Mechanism Box)**
Each transformer unit of OLTC gear shall have following features:

- OLTC shall be suitable for manually handle operated and electrically motor operated. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.
- OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device/handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:
  a. Mechanical tap position indicator which shall be clearly visible from near the transformer.
  b. A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting.
  c. Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.

d. The manual control considered as back up to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.
e. The manual operating mechanism shall be labeled to show the direction of operation for raising the voltage and vice-versa.
f. An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

- For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is in use. It shall not be possible for any two controls to be in operation at the same time. Transfer of source in the event of failure of one AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit. The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:
  i. A circuit breaker/contactor with thermal overload devices for controlling the AC auxiliary supply to the OLTC motor
  ii. Emergency Push Button to stop OLTC operation
  iii. Cubicle light with door switch provided with anti-condensation metal clad heaters to prevent condensation of moisture
  iv. Padlocking arrangement for hinged door of cabinet
  v. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
  vi. The cabinet shall be tested at least IP 55 protection class.

- All relays and operating devices shall operate correctly at any voltage within the limits specified below. In case auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

| Nominal Voltage | Variation in Voltage | Frequency in Hz | Phase/Wire | Neutral Connection |
|---|---|---|---|---|
| 415 V | +/- 10% | 50 +/- 5% | ¾ Wire | Solidly earthed |
| 240 V | +/- 10% | 50 +/- 5% | ½ Wire | Solidly earthed |
| 220 V | 190 V to 240 V | DC | Isolated 2 wire system | - |
| 110 V | 95 V to 120 V | DC | Isolated 2 wire system | - |
| 48 V | - | DC | 2 wire system (+) earthed | - |

Note: Combined voltage and frequency shall be limited to +/- 10%

- In case auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.
- Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations / repeat commands.
- Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.
- OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in CMB (for single phase unit) and input to Digital RTCC/SCADA system.
- 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (i.e. from CMB, Digital RTCC, SCADA etc.) shall be cut-off/blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from CMB/ Digital RTCC/SCADA etc.

shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

- Following minimum contacts shall be available in DM Box, which shall be wired to CMB for single phase unit. Further these contacts shall be wired to Digital RTCC panel:
  a. INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
  b. OLTC motor overload protection
  c. Supply to DM Motor fail
  d. OLTC IN PROGRESS
  e. Local / Remote Selector switch position
  f. OLTC upper/lower limits reached
- All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked / labeled for the purpose of identification.
- A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

**3.17.23.0 Digital RTCC Panel**

The digital RTCC relay shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as **Digital RTCC relay**) to remotely control and monitor OLTC.

The contractor shall also provide Digital RTCC panel consisting of 4 Nos. Digital RTCC relays. Further, one spare Digital RTCC relay shall also be provided in the same panel. Each digital RTCC relay shall be used to control 1 bank of transformers (i.e., 1 No. 3-Phase unit)

Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT / VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.

All Digital RTCC Relays shall be of same make for smooth integration of these relays for parallel operations of all transformers in the substation.

The RTCC Panel shall be provided with digital RTCC relay having Raise/Lower push buttons, Manual/ Automatic mode selection features, Master / Follower/ Independent/Off mode selection features for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.

**In Manual Mode**: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.
**In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.
**Master / Follower/ Independent/ Off mode**
Master / Follower parallel operation is required with Group simultaneous feature in Digital RTCC relay. Master-follower scheme implies that controlled decision shall be taken by the Master and control actions (Raise/Lower tap position) shall be executed simultaneously by Master & Follower units. Same logic needs to be implemented in digital RTCC relays.

**Master Position**: If the digital RTCC relay is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

**Follower Position**: If the digital RTCC relay is in Follower position, control of OLTC shall be possible only from panel where master mode is selected.

**Independent Position**: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected. Suitable interlock arrangement shall be provided to avoid unwanted/inconsistent operation of OLTC of the transformer

**Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the complete bank of three 1-phase transformers / 3-Phase Transformers. Individual 1-phase OLTC operation shall not be possible from the remote-control panel.

Digital RTCC relays shall communicate with SCADA using IEC 61850 through FO port to monitor, parameterize & control the OLTC. Any software required for this purpose shall be supplied. The supplied software shall not have restriction in loading on multiple computers for downloading and analysing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time.

The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA, with a facility to have the possibility of additional set points command from SCADA.

Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. IEC- 61850 GOOSE messaging between Digital RTCC relays for OLTC parallel operation is not permitted. Suitable communication hardware shall be provided to communicate up to distance of 1km between digital RTCC relays. Scope shall also include communication cables between digital RTCC relays. Cables as required for parallel operation of OLTCs of all transformers (including existing transformers wherever required) from Digital RTCC relays shall be considered included in the scope of bidder.

The Digital RTCC relay shall have additional programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employer's future use. It shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement.

The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay. "Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be affected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs:

a. INCOMPLETE STEP alarm
b. OLTC motor overload protection alarm
c. Supply to DM Motor fail alarm
d. OLTC IN PROGRESS alarm
e. Local / Remote Selector switch positions in DM Box
f. OLTC upper/lower limits reached alarm
g. OLTC Tap position indications for transformer units
h. Independent-combined-remote selector switch positions of CMB (In case of single-phase transformer)
i. 415V, AC Mail Supply Fail.
j. 415V, AC Standby Supply Fail

In case of parallel operation or 1-Phase Transformer unit banks, OLTC out of step alarm shall be generated in the digital RTCC relay for discrepancy in the tap positions.

**3.17.24.0 SCADA Integration and Interconnection**

All required power & control cables including optical cable, patch chord (if any) upto MB (for 3-Ph unit) shall be in the scope of contractor. Further, any special cable between MB (for 3-Ph unit) to switchyard panel room/control room shall be under the present scope. All cable from RTCC to OLTC Drive Mechanism Box shall be provide (if applicable).

Fiber optic cable, power cable, control cables, as applicable, between MB (for 3-Ph unit) or Common MB (for 1-Ph unit) to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of EPC contractor.

Cooling and OLTC of transformers shall be monitored and controlled from SCADA.

SCADA Integration of online monitoring equipment (if applicable):

All the online monitoring equipment i.e., Online Dissolved Gas (Multi-gas) and Moisture Analyser, On-line insulating oil drying system (Cartridge type) etc. provided for individual transformer unit including Spare (if any), are IEC 61850 compliant (either directly or through a Gateway). The monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in IMB or CMB. The switch shall be powered by redundant DC supply (110V or as per available Station DC supply). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg. C.

**3.17.25.0 Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ Common Marshalling Box/ Junction Box / Outdoor cubicle and Digital RTCC Panel:**

Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet /individual marshalling box, Digital RTCC panel (as applicable) shall be provided.

Individual Marshalling Boxes and Cooler control Box shall be tank mounted or ground mounted. The gland plate shall be at least 450 mm above ground level (for ground mounted panel). Preferably, the transformer Marshalling Box and Cooler control Box (for 3-ph Transformer) shall be ground mounted, however feasibility shall be decided during detailed engineering depending upon site conditions.

The cooler control cabinet / individual marshalling box, common marshalling box, Junction box and all other outdoor cubicles (**except OLTC Drive Mechanism box**) shall be made of stainless-steel sheet of minimum grade of SS304 and of minimum thickness of 1.6 mm (SS 316 for coastal area). Digital RTCC panel shall be made of CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure –D**.

The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS 13947/IEC: 60947.

All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced, if necessary, to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets / Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. Thermostat controlled space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application.

**3.17.26.0 Current Transformer**

Current transformers shall comply with IS 16227 (Part 1 & 2)/IEC 61869 (part 1 & 2).

It shall be possible to remove the turret mounted current transformers from the Transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

Technical Parameters of Bushing CTs and Neutral CTs are enclosed at **Annexure – G.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Purchaser's approval before proceeding with the design of bushing current transformers.

Secondary resistance and magnetising current characteristics of PX class (protection) (as per IEC) CT of same rating shall be similar. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

**3.17.27.0 Hand Tools:**

One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one ), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied.

**3.17.28.0 Test Kit: N/A**

**3.17.29.0 Fittings & accessories**

The following fittings & accessories (as applicable) shall be provided with each transformer covered in this specification. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the transformer are deemed to be included:

- Conservator for main tank with air cell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge (with canopy) with high and low oil level alarm contacts and prismatic oil level gauge and Dehydrating Silica gel Filter Breather with flexible connection pipes to be used during replacement of any silica gel breather.
  Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and Dehydrating Silica gel Filter Breather with flexible connection pipes to be used during replacement of any silica gel breather.

- Oil preservation equipment, Thermosyphon filter with valves.
- Pressure relief devices including canopy with special shroud to direct oil
- Sudden pressure relief relay including canopy.
- Buchholz relay double float, reed type with canopy and isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts (gas collecting device)
- Air release plug
- Conservator air cell rupture detection relay
- Inspection openings and covers
- Bushing of each type with metal parts and gaskets to suit the termination arrangement

- Winding & Oil temperature indicators
- Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs
- Protected type mercury or alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator as applicable
- Rating and diagram plates (in Hindi & English) on transformers and auxiliary apparatus
- Roller Assembly **(as per clause 3.17.13.1.6)**
- On load tap changing gear, OLTC DM Box, Off Circuit Tap Changer (OCTC) individual marshalling box / Cooler control cabinet, Common Marshalling Box, Fibre optic sensor box and Digital RTCC Panel as applicable
- Cooling equipment
- Bushing current transformers, Neutral CT (if applicable)
- Oil flow indicators (if applicable)
- Terminal marking plates
- Valves schedule plate &All the valves **as per clause 3.17.13.1.1.4 and 3.17.21.0**.
- **Valves List**: Bottom oil sampling valve, Drain valves, Filter valves at top and bottom with threaded male adaptors, Shut off valves on the pipe connection between radiator bank and Transformer tank, Shut off valves on both sides of Buchholz relay, Sampling gas collectors for Buchholz relay at accessible height, Valves for Radiators, Valve for vacuum application, Valve for on line DGA, valves for Drying out system, Flow sensitive conservator Isolation valve, Valve for UHF sensors, valves for NIFPS system etc.
- Ladder (suitably placed to avoid fouling with bushing or piping) to climb up to the transformer tank cover with suitable locking arrangement to prevent climbing during charged condition. Additional ladder for conservator in case it is not tank mounted.
- Suitable Platform for safe access of Flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from transformer top.
- Haulage lugs
- Neutral bus connection arrangement. (3-Phase Transformer)
- Brass/tinned copper grounding bar supported from the tank by using porcelain insulator and flexible conductor for earthing of neutral, HV & IV terminals.
- On line insulating oil drying system.
- Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment
- On line dissolved Hydrogen and Moisture Measuring Equipment
- Fibre optic sensor-based temperature measuring system.
- Nitrogen Injection Type Fire Prevention & Extinguishing System.
- Automatic Mulsifire System (or High Velocity Water Spray System)
- RTCC All Cables (Power, control and shielded / twisted pair for 4-20mA cable from Transformer MB, Cooler control cubicle, etc. (as applicable) to CMB shall be under the present scope. Any special cable if required to be included upto panel/ employer's C&R panel.
- Managed Ethernet switch, LIU patch cords etc. shall be provided in CMB/MB. All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

**3.17.30.0 Inspection and Testing**

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. 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 in the form of detailed quality plan duly approved by Purchaser for necessary implementation. All accessories and components of transformer shall be purchased from approved soured of purchaser. All process tests, critical raw material tests and witness / inspection of these testing shall be carried out as per approved manufacturing quality plan (MQP) by purchaser.

**3.17.31.0 Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.
The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.
The contractor shall carry out type & routine tests as per "**Annexure-H & Annexure-I".** All tests shall be done in line with IEC: 60076 and the test procedures as mentioned in "**Annexure-H".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

**3.17.32.0 Type Tests on fittings:**
Following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with drawings and GTP of the equipment / fittings.

1) Bushing (Type Test as per IEC:60137 including Snap back & Seismic test for 400 kV and above voltage class bushing)
2) OLTC (Test as per IEC:60214 and IP-55 test on driving mechanism box)
3) Buchholz relay
4) OTI & WTI
5) Pressure Relief device Test (including IP 55 test in terminal box)
6) Sudden Pressure Relay Test (including IP 55 test in terminal box)
7) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
8) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016
9) Marshalling & common marshalling box and other outdoor cubicle (IP-55 test)
10) RTCC (IP-43)

**3.17.33.0 Pre-Shipment Checks at Manufacturer's Works**
Check for inter-changeability of components of similar transformers for mounting dimensions.

Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

Before dispatch of Transformer from factory, following impact recorder settings are to be implemented for graphical analysis:

> 1g: Start recording
> 2g: Warning
> 3g: Alarm

Further, drop-out setting shall be 1g and threshold setting shall be in the range of 5g to 10g.

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

Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

**3.17.34.0 Inspection and Testing at Site**
The Contractor shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the Purchaser is given below. However, it is contractor's responsibility to draw up and carry out such a Programme duly approved by the Purchaser. Testing of oil sample at site shall be carried out as per specification.

**3.17.35.0 Receipt and Storage Checks**

Check and record condition of each package, visible parts of the transformer etc. for any damage. Check and record the gas pressure in the transformer tank as well as in the gas cylinder. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

**3.17.36.0 Installation Checks**

Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc. Check the direction of rotation of fans and pumps and check the bearing lubrication. Check whole assembly for tightness, general appearance etc.

Oil leakage test
Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

Leakage check on bushing before erection
Measure and record the dew point of gas in the main tank before assembly.

**3.17.37.0 Commissioning Checks**
Check the colour of silica gel in silica gel breather. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

Check the bushing for conformity of connection to the lines etc.
Check for correct operation of all protection devices and alarms/trip:
i. Buchholz relay
ii. Excessive winding temperature
iii. Excessive oil temperature
iv. Low oil flow
v. Low oil level indication
vi. Fan and pump failure protection

Check for the adequate protection on the electric circuit supplying the accessories.
Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

i) Control wiring
ii) Cooling system motor and control
iii) Main windings
iv) Tap changer motor and control

Check for cleanliness of the transformer and the surroundings.
2 kV for 1-minute test between bushing CT terminal and earth
Phase out and vector group test.
Ratio test on all taps

Magnetising current test
Capacitance and Tan delta measurement of winding and bushing
Frequency response analysis (FRA)- FRA equipment shall be arranged by purchaser.

DGA of oil just before commissioning and after 24 hours energisation at site

Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

Continuously observe the transformer operation at no load for at least 24hours.
Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures forward to Purchaser for future record.

**3.17.38.0 NITROGEN INJECTION TYPE FIRE PREVENTION & EXTINGUSHING SYSTEM**

Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer tank and the fire during internal faults resulting from arc and also to extinguish the external oil fires on transformer due to tank explosion and/or external failures like bushing fires, OLTC fires and fire from surrounding equipment, etc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a predetermined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e., core coil assembly). Electrical isolation of transformer shall be an essential pre-condition for activating the system.

**3.17.38.1.0 Operational Controls**
The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

**3.17.38.1.1 Prevention of transformer from explosion and fire**
To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

**3.17.38.1.2 Prevention of transformer from fire**
In case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

**3.17.38.2.0 Operation of System**
On receiving activation signal, the following shall take place:

i) Open the quick opening drain valve to drain the top layer oil
ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank
iii) Open the Nitrogen regulator valve to inject Nitrogen into the transformer tank to create stirring of oil.
There shall be interlock to prevent activation of the system if the transformer is not electrically isolated.
There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

**3.17.38.3.0 Technical Particulars**
The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from AEGCL.
Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in Data Sheet. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor's responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box: -

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer
- Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

**3.17.38.4.0 Details of Supply of System Equipment and Other Related Activities:**

The scope of supply shall include the following items and any other items required for safe and trouble-free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:
   - Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
   - Oil Drain Assembly including oil drain pipe extension of suitable size for connecting pipes to oil pit
   - Mechanical release device for oil drain and nitrogen release
   - Limit switches for monitoring of the systems
   - Panel lighting
   - Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
   - Back up pressure switch to operate nitrogen gas valve
   - Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signaling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

Detailed specification of Nitrogen Injection Type Fire Protection System (NIFPS) shall be as per **Annexure-P.**

**3.17.39.0 Under Ground Oil Storage Tank**

Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have non-Corrosive, water proof, epoxy coated (from Inside) mild steel (minimum thickness 6 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **Clause 3.17.19.0**. The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground

storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rain water. The design of tank and pit shall be finalized during detailed engineering. **All underground oil and gas storage tanks design shall be certified by petroleum and explosive safety organisation, Nagpur, India.**

**3.17.39.1.1 Installation and pre-commissioning test**

After installation the system pre-commissioning tests shall be carried out jointly with the Owner's representative before the system is put in service.

**3.17.39.1.2 Online Insulating oil drying system**

On-line insulating oil drying system (Cartridge type) along with all required accessories shall be provided with each transformer. In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each transformer shall be provided with an on-line insulating oil drying system of adequate rating with proven field performance. This system shall be tank/cooler bank mounted and no separate foundation shall be provided. This on-line insulating oil drying system shall be

(i). Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity.

(ii). The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system. The moisture in inlet & outlet oil (PPM) shall have to be displayed in Local SCADA besides local HMI.

(iii). Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

Addition detailed specification of On-line insulating oil drying system shall be as per **Annexure-O.**

**3.17.40.0 On Line Dissolved Hydrogen and Moisture Monitor**

The Monitor shall be a microprocessor based Intelligent Electronic Device (IED), designed to continuously detect and measure dissolved Hydrogen and Water content, even at very low concentrations, in Transformer Oil. It should be easy to install and it should be possible to retrofit it on an energized transformer, without shutting down the transformer.

The monitor shall be designed for permanent outdoor use in high voltage sub-station environments, for ambient temperatures of 0 deg C to 55 deg C and oil temperatures of 5 deg C to 105 deg C.

The monitor shall be suitable to detect and measure dissolved Hydrogen in ppm, without significant interference from other fault and atmospheric gases. The monitor shall also be suitable to detect Water Content measured in ppm.

The Hydrogen sensors shall have long lifetime in oil. The sensors shall be able to withstand pressure from vacuum to 10 psi.

**3.17.40.1.0 Technical Parameters:**

| Sr. No. | Parameters | Requirements |
|---|---|---|
| 1 | **The measurement range / Output:** | |

| | | |
|---|---|---|
| | Hydrogen Dissolved in oil | 0 to 2000 ppm, with 4 – 20 mA output |
| | Water Dissolved in oil | 0 to 95% RS, with 4 – 20 mA output |
| **2** | **Alarms/Indication (High & Very High)** | |
| | Hydrogen | Programmable NO/NC contacts, |
| | Water | Programmable NO/NC contacts, |
| **3** | **Environment** | |
| | Operating Ambient Temperature | 0 to + 55 deg C |
| | Operating Oil Temperature | 5 to + 105 deg C |
| | Pressure Withstand, (Oil side) | Full Vacuum to 10 psi. |
| **4** | Exterior enclosure and components | made of corrosion proof material to IP - 55 |
| **5** | Communications | RJ45/RS–232 ports and suitable for Ethernet connectivity |

Addition detailed specification of On-Line Dissolved Hydrogen and Moisture Monitor shall be as per **Annexure-N.**

**3.17.41.0 Condition Controlled Maintenance Free Type Breather**

The main Transformer tank conservator shall be fitted with a Maintenance-Free type silica gel Breather which shall be equipped with a humidity sensor, a condition-based microprocessor control unit and LED status indication.

**3.17.41.1.0 Dehydrating breather's operating principle:**

When the oil conservator breaths-in (e.g., at reduced load), the air flows through a filter made of high-grade steel wire mesh. The equipment fitted with filter & the dust cap, filters the dust, sand and other dirt particles from the air. The filtered air flows through the desiccant chamber filled with colourless, moisture absorbing pellets and are dehydrated. The dehydrated air rises further via the pipe in the oil conservator. The desiccant is dehydrated by the built-in heating unit which is controlled by sensors, thus obviating the need for periodic desiccant replacement. The dehydrating breather is mounted on the pipe to the oil conservator at a height of 1200 mm approximately from transformer rail top level.

**3.17.41.1.1 Technical Features:**

Material & External Construction of the Breather shall be such that all external parts are suitable for outdoor use & resistive to transformer oil, ultraviolet rays, pollution & salt water and shall work without any trouble for ambient temperature between $0^{o}$ C to $+80^{o}$ C.

Following LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:

a. LED for Power of control unit - ON
b. LED for Filter heater- ON
c. LED for Anti-condensation heater (of control unit) - ON
d. LED & relay contact for "Device Error"
e. LED & relay contact for Regeneration active (De-humidification in process)
f. Analogue output signal (4-20mA) for the Temperature of air (in filter unit / pipe).

The Breather shall be equipped with test button which should allow to carry out a self-test and to check the functions like relay circuits, heating or the signal transmission in the control room, etc. at any time.

Control unit shall be equipped with a USB / RS 485 port for downloading the operational data logged by the unit. All necessary software required for downloading and analysing the logger data shall also be provided by the supplier. Supply of Laptop/PC for above software is not envisaged.

The moisture and temperature measurement system (sensor) installed should be modular making it easy to replace the same if at all the same is necessary during the service of breather.

The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied with the equipment.

Degree of Protection shall be at least IP55 for which type Test report shall be submitted. Necessary protective devices shall be provided in order to protect the equipment against over voltages & high frequency interference.

The control unit shall be equipped with suitable heater to prevent moisture condensation.

The size of Condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.

For OLTC conservator, conventional breather shall be supplied as per technical specification.

Condition Controlled Maintenance Free Type Breather of alternate proven technology shall also be acceptable.

Addition detailed specification of Condition Controlled Maintenance Free Type Breather shall be as per **Annexure-S.**

**3.17.42.0 Automatic Mulsifire System (or High Velocity Water Spray System)**

**3.17.42.1.0 Description:**

This system is widely used for firefighting of outdoor transformers. Spray type fire protection essentially consists of a network of project or sand an array of heat detectors used to sense high temperature near the transformer to be protected. If the temperature exceeds the set value, the automatic Mulsifire system sprays water at high pressure through a Deluge valve from the pipe network laid for this system. Fire detectors located at various strategic points are on the surface of the transformer to control fire on any burning oil spilled over.

**3.17.42.1.1 Subsystems used to make a complete Mulsifire system:**

a) Main Hydrant

Thisisusedtocarrythewatertovariouspartsoftheswitchyardortransformersubstationand forms the backbone of the system. Sturdy corrosion-free pipes and valves are used for this purpose. The materials should be able to withstand fire for a reasonable duration.

b) Fire Detector

Fire detectors can either be thermocouples or specially designed bulbs which burst when they experience a high temperature and release any valves or checking device to start the water supply.

c) Ring Mains and Nozzles

Ring mains, which surround the transformer, are provided to feed the water to the nozzles at various levels. Since the water pressure is high, the ring mains should be designed to withstand this pressure. Nozzles should be located such that the water spray, in the event of a fire, envelopes the entire surface of the transformer. The whole system should be periodically checked to detect any leakages.

d) Pumps

Pumps are provided to fill the hydrants initially and to maintain its pressure. Pumps driven by electrical motors are a standard provision; however, the standby pumps should preferably be diesel engine driven. It is recommended that the main and standby pumps in a pump house be segregated.

**3.17.42.1.2 Electrical Safety**

As per IEEMA specification, from safety considerations, the following electrical clearances are recommended between the Mulsifire system pipe work and live parts of the transformer to be protected.

- 420kVbushing 3500mm
- 245kVbushing 2150mm
- 145kVbushing 1300mm
- 52kVbushing 630mm
- 36kVbushing 320mm

**3.17.42.1.3 Installation Care**

- Deluge Valve shall be water pressure operated manual reset type.
- Each Deluge valve shall be provided with a local panel from which will enable manual electrical operation of the valve.
- In addition to this, each valve shall be provided with local operation latch.
- Test valves shall simulate the operation of Deluge valves and shall be of quick opening type.

**3.17.43.0 CENTRE OF GRAVITY:**

The center of gravity of assembled transformer shall be as low and as near the vertical center line as possible. The transformer shall be stable with and without oil. The location of the center of gravity, relative to track shall be clearly marked in the outline drawing, accompanying bid.

**Annexure – A 1.0**
**1.0 Technical Particulars / Parameters of Transformers**
**(220/132/33 kV, 200 MVA 3-Phase Auto Transformer)**

| Sl.No. | Description | Unit | TECHNICAL PARAMETERS | |
|---|---|---|---|---|
| 1. | Rated Capacity | | | |
| | HV | MVA | 200 | |
| | IV | MVA | 200 | |
| | LV (Tertiary) | MVA | 5 MVA active loading | |
| 2. | Voltage ratio | kV | 220/132/33 | |
| 3. | Single / Three Phase Design | | 3 (Three) | |
| 4. | Applicable Standard | | IEC 60076 /IS 2026 | |
| 5. | Frequency | Hz | 50 | |
| 6. | Cooling & Percentage Rating at different cooling | | ONAN/ONAF/ (OFAF or ODAF): 60% / 80%/100% | |
| 7. | Cooler Bank Arrangement | | 2 X 50% | |
| 8. | Type of Transformer | | Constant Ohmic impedance type | Constant percentage impedance type |
| 9. | HV-IV Impedance at 75 Deg C | | | |
| i) | Max. Voltage tap | % | 10.3 | 13.0 |
| ii) | Principal tap | % | 12.5 | 12.5 |
| iii) | Min. Voltage tap | % | 15.4 | 14.0 |
| iv) | Tolerance on Impedance | % | As per IEC | |
| 10. | Service | | Outdoor | |
| 11. | Duty | | Continuous | |
| 12. | Overload Capacity | | IEC 60076-7 / IS 6600 | |
| 13. | Temperature rise over 50 deg C Ambient Temp | | | |
| i) | Top oil measured by thermometer | O C | 50 | |
| ii) | Average winding measured by resistance method | O C | 55 | |
| iii) | Winding hot spot | O C | 66 | |
| 14. | Tank Hotspot Temperature | O C | 95 | |
| 15. | Windings | | | |
| i) | Lightning Impulse withstand Voltage | | | |
| | HV | kVp | 950 | |
| | IV | kVp | 650 | |
| | LV | kVp | 250 | |
| | Neutral | kVp | 95 | |
| ii) | Switching Impulse withstand Voltage | | | |
| | HV | kVp | 750 | |
| iii) | One Minute Power Frequency withstand Voltage | | | |

| | | | |
|---|---|---|---|
| | HV | kVrms | 395 |
| | IV | kVrms | 275 |
| | LV | kVrms | 95 |
| | Neutral | kVrms | 38 |
| iv) | Neutral Grounding | | Solidly grounded |
| v) | Insulation | | |
| | HV | | Graded |
| | IV | | Graded |
| | LV | | Uniform |
| vi) | Tertiary Connection | | Delta |
| vii) | Tan delta of winding | % | ≤0.5% |
| 16. | Vector Group (3 –ph)<br>(Unless specified differentlyelsewhere) | | YNa0d11 |
| 17. | Tap Changer | | OLTC |
| i) | Tap Range and no. of steps | | –5% to +10% of HV variation in the step of 1.25%, 12Steps |
| ii) | Location of Tap changer | | On the 132 kV side of the series winding |
| iii) | Design | | Constant flux voltage variation type as per cl. 6.2of IEC 60076 part-I |
| iv) | Tap control | | Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow |
| 18. | Bushings | | |
| i) | Rated voltage | | |
| | HV | kV | 245 |
| | IV | kV | 145 |
| | LV | kV | 52 |
| | Neutral | kV | 36 |
| ii) | Rated current (Min.) | | |
| | HV | A | 800 |
| | IV | A | 1250 |
| | LV | A | 800 |
| | Neutral | A | 1000 |
| iii) | Lightning Impulse withstand Voltage | | |
| | HV | kVp | 1050 |
| | IV | kVp | 650 |
| | LV | kVp | 250 |
| | Neutral | kVp | 170 |
| iv) | Switching Impulse withstand Voltage | | |
| | HV | kVp | 850 |
| v) | One Minute Power Frequency withstand Voltage | | |
| | HV | kVrms | 505 |

| | | | |
|---|---|---|---|
| | IV | kVrms | 305 |
| | LV | kVrms | 105 |
| | Neutral | kVrms | 77 |
| vi) | Minimum total creepagedistances | | |
| | HV | mm | 6125 |
| | IV | mm | 3625 |
| | LV | mm | 1300 |
| | Neutral | mm | 900 |
| viii) | Max Partial discharge level at $U_m$ | | |
| | HV | pC | 10 |
| | IV | pC | 10 |
| | LV | pC | 10 |
| 19. | Max Partial discharge level at 1.5 *Um/√3 | pC | 100 |
| 20. | Max Noise level at rated voltage and at principal tap at no load and all cooling active | dB | 75 |
| 21. | **Maximum Permissible Losses of Transformers** | | **200 MVA** |
| i) | Max. No Load Loss at ratedvoltage and frequency | kW | 35 |
| ii) | Max. Load Loss at rated currentand at $75^O$ C for HV and IV windings | kW | 260 |
| iii) | Max. $I^2R$ Loss at rated current and at $75^O$ C for HV and IV windings | kW | 190 |
| iv) | Max. Auxiliary Loss at rated voltage and frequency | kW | 8 |

**Notes:**

1) For parallel operation with existing transformer, the impedance, OLTC connection &range and the winding configuration (if necessary) is to be matched.
2) No external or internal Transformers are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3) Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4) The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No-load Loss) > Cooler Loss (Auxiliary Loss)".**
5) External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3)/IEC60076-3

**Annexure–B**

**Design Review Document**

| Sr. No. | Description |
|---|---|
| 1. | Core and Magnetic Design |
| 2. | Over-fluxing characteristics upto 1.7Um |
| 3. | Inrush-current characteristics while charging from HV & IV respectively. |
| 4. | Winding and tapping design |
| 5. | Short-circuit withstand capability including thermal stress for min. 2 Sec. |
| 6. | Thermal design including review of localised potentially hot area. |
| 7. | Cooling design |
| 8. | Overload capability |
| 9. | Eddy current losses |
| 10. | Seismic design, as applicable |
| 11. | Insulation co-ordination |
| 12. | Tank and accessories |
| 13. | Bushings |
| 14. | Tap changers |
| 15. | Protective devices |
| 16. | Fans, pumps and radiators |
| 17. | Sensors and protective devices– its location, fitment, securing and level of redundancy |
| 18. | Oil and oil preservation system |
| 19. | Corrosion protection |
| 20. | Electrical and physical Interfaces with substation |
| 21. | Earthing (Internal & External) |
| 22. | Processing and assembly |
| 23. | Testing capabilities |
| 24. | Inspection and test plan |
| 25. | Transport and storage |
| 26. | Sensitivity of design to specified parameters |
| 27. | Acoustic Noise |
| 28. | Spares, inter-changeability and standardization |
| 29. | Maintainability |
| 30. | PRD and SPR (number & locations) |
| 31. | Conservator capacity calculation |
| 32. | Winding Clamping arrangement details with provisions for taking it “in or out of tank” |
| 33. | Conductor insulation paper details |
| 34. | The design of all current connections |
| 35. | Location & size of the Valves |

**Annexure-C**
**UNDERTAKING**

We, M/s. ---------- , have participated in Tender No. ---------- for supply of:

1) -------- kV class -------- MVA Auto/Power Transformers
2) -------- kV class -------- MVA Auto/Power Transformers
3) -------- kV class -------- MVA Auto/Power Transformers
4) -------- kV class -------- MVA Auto/Power Transformers

to AEGCL. In accordance with the terms of the said tender, we hereby undertake that we shall use imported prime CRGO steel lamination and not the second grade CRGO steel lamination for the manufacturing of the transformers against this Tender. Further, we shall produce the following documents at the time of inspection of transformers:

a) Invoice of supplier
b) Mill's Test Certificate issued by Customs
c) Packing list
d) Bill of lading
e) Bill of entry Certificate issued by Customs.

Signature of the Tenderer :
Name :
Designation :
Seal of the Company :

**(On Rs 100/- stamp paper duly notarized)**

**Annexure – D**

**Painting Procedure**

| PAINTING | Surface preparation | Primer coat | Intermediate undercoat | Finish coat | Total dry Film thick-Ness (DFT) | Colour shade |
|---|---|---|---|---|---|---|
| Main tank, pipes, conservator tank, oil storage tank& DM Box etc. (External surfaces) | Shot Blast cleaning Sa 2 ½* | Epoxy base Zinc primer (30-40µm) | Epoxy high build Micaceous iron oxide (HB MIO) (75µm) | Aliphatic polyurethane (PU) (Minimum 50µm) | Minimum 155µm | RAL 7035 |
| Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces) | Shot Blast cleaning Sa 2 ½* | Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint | -- | -- | Minimum 30µm | Glossy white for paint |
| Radiator (External surfaces) | Chemical / Shot Blast cleaning Sa 2 ½* | Epoxy base Zinc primer (30-40µm) | Epoxy base Zinc primer (30-40µm) | PU paint (Minimum 50µm) | Minimum 100µm | Matching shade of tank/ different shade aesthetically matching to tank |
| | **contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40µm (min)** | | | | | |
| Radiator and pipes up to 80 NB (Internal surfaces) | Chemical cleaning, if required | Hot oil proof, low viscosity varnish or Hot oil resistant, non- | -- | -- | -- | -- |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | corrosive Paint | | | | |
| Digital RTCC Panel | Seven tanks process as per IS:3618 | Zinc chromate Primer | -- | EPOXY paint with PU top coat or POWDER | Minimum 80µm / for Powder Coated | RAL 7035 shade for exterior and Glossy |
| | & IS:6005 | (Two coats) | | coated | Minimum 100µm | white for interior |
| Control cabinet / Marshalling Box - No painting is required. | | | | | | |

Note: (*) Indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

**Annexure– E**

**UNUSED INHIBITED HIGH-GRADE INSULATING OIL PARAMETERS**

| Sl. No. | Property | Test Method | Limits |
|---|---|---|---|
| **A** | **Function** | | |
| 1a. | Viscosityat40degC | IS1448Part25orISO3104orASTM D7042 | (Max.)12mm$^2$/s |
| 1b. | Viscosityat-30degC | | (Max.)1800mm$^2$/s |
| 2. | Appearance | A representative sample of the oil shall be examined in a 100mmthicklayer, at ambient temperature | The oil shall be clear and bright, transparent and free from suspended matter or sediment |
| 3. | Pour point | IS1448Part10/Sec2orISO3016 | (Max.)-40degC |
| 4. | Water content<br>a) For bulk supply<br>b) For delivery in drums | IEC60814 | (Max.)30<br>mg/kg<br>40mg/kg |
| 5. | Electric strength (breakdown voltage) | IS 6792 or IEC60156 | (Min.) 50kV (new unfiltered oil) /70kV (after treatment) |
| 6. | Density at 20 deg C | IS1448Part16orISO12185orISO3675 or ASTM D7042 | Max0.895g/ml |
| 7. | Dielectric dissipation factor (tan delta) at90degC | IS16086orIEC60247orIEC61620 | (Max)0.0025 |
| 8. | Negative impulse testing KVp @25degC | ASTMD-3300 | 145(Min.) |
| **B** | **Refining/Stability** | | |
| 1. | Colour | ISO2049 | L0.5(lessthan0.5) |
| 2. | Acidity | IEC62021-2or62021-1 | (Max)0.01mgKOH/g |
| 3. | Interfacial tension at 27degC | IEC62961 or ASTM D971 | 0.043N/m(min) |
| 4. | Total sulphur content | ISO14596 or ISO8754 | 0.05 % (Max.)<br>(before oxidation test) |
| 5. | Corrosive sulphur | DIN51353 | Not-Corrosive |
| 6. | Potentially corrosive sulphur | IEC62535 | Not-Corrosive |
| 7. | DBDS | IEC62697-1 | Not detectable(<5mg/kg) |
| 8. | Presence of oxidation inhibitor | IS 13631 or IEC60666 | 0.08%(Min.) to0.4%(Max.)<br>Oil should contain no other additives. Supplier should declare presence of additives, if any. |
| 9. | Metal passivator additives | IEC60666 | Not detectable(<5mg/kg) |
| 10. | 2-Furfural content and related compound content | IS 15668 or IEC 61198 | Not detectable (<0.05 mg/kg) for each individual compound |
| **C** | **Performance** | | |

| | | | |
|---|---|---|---|
| 1. | Oxidation stability | IEC 61125 (method c) Testduration500hour | |
| 2. | Total acidity* | 4.8.4 of IEC61125:2018 | 0.3mgKOH/g(Max.) |
| 3. | Sludge* | 4.8.1 of IEC61125:2018 | 0.05 %(Max.) |
| 4. | Dielectric dissipation factor (tandelta) at 90degC | 4.8.5 of IEC61125:2018 | 0.05(Max.) |
| | *Values at the end of oxidation stability test | | |
| **D** | **Health, safety and environment (HSE)** | | |
| 1. | Flashpoint | IS1448Part21or ISO2719 | (Min.)135degC |
| 2. | PCA content | IP346 | < 3% |
| 3. | PCB content | IS 16082 or IEC61619 | Not detectable (< 2mg/kg) |
| **E** | **Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:** | | |
| 1 | Breakdown voltage (BDV) | | 70kV(min.) |
| 2 | Moisture content | | 5ppm(max.) |
| 3 | Tan-delta at 90°C | | 0.005(max) |
| 4 | Interfacial tension | | 0.04N/m(min) |
| **F** | **Each lot of the oil shall be tested prior to filling in main tank at site for the following:** | | |
| 1 | Breakdown voltage (BDV) | | 70kV (min.) |
| 2 | Moisture content | | 5ppm(max.) |
| 3 | Tan-delta at 90°C | | 0.0025(Max) |
| 4 | Interfacial tension | | 0.04N/m(min) |
| **G** | **After filtration & settling and prior to energisation at site oil shall be tested for following:** | | |
| 1 | Breakdown voltage (BDV) | | 70kV (min.) |
| 2 | Moisture content at hot condition | | 5ppm(max.) |
| 3 | Tan-delta at 90°C | | 0.005(Max) |
| 4 | Interfacial tension | | More than 0.04 N/m |
| 5 | *Oxidation Stability | | |
| | a) Acidity | | 0.3 (mg KOH/g) (max.) |
| | b) Sludge | | 0.05 %(max.) |
| | c)Tandeltaat90°C | | 0.05(max.) |
| 6 | *Total PCB content | | Not detectable (lessthan2mg/kg total) |
| *Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning For approval of AEGCL. | | | |

Note: Supplier shall declare the chemical family and function of all additives and the concentrations in the cases of inhibitors, antioxidants and passivators.

**Annexure- F**

## RATING & DIAGRAM PLATE

The transformer shall be provided with a rating plate of weather proof material, fitted in a visible position, showing the appropriate items indicated below. The entries on the plate shall be in English in in delibly marked. Minimum Information to be provided on the plate:

| | | | | | |
|---|---|---|---|---|---|
| **Manufacturer's name, country and city where the transformer was assembled** | | | | | |
| **MVA Rating, Voltage ratio, Type of transformer (for example 200 MVA220/132KV Auto Transformer)** | | | | | |
| Type of Cooling | | | Applicable Standard | | |
| Rated Power at different cooling | | | Rated frequency | Hz | |
| HV/IV | MVA | --/--/-- | Number of phases | | |
| LV | MVA | | %Impedance/Ohmic Impedance | | |
| Rated Voltage | | | (a)HV-IV | | |
| HV | kV | | Min.tap | % | |
| IV | kV | | Principal Tap | % | |
| LV | kV | | Max.Tap | % | |
| Rated Current | | | (b) HV-LV | % | |
| HV | A | | (c)IV-LV | % | |
| IV | A | | Vector Group | | |
| LV | A | | Core mass | kg | |
| Rated Thermal Short Circuit withstand | kA(sec) | | Copper Mass | | |
| Capability Current and Duration | | | | | |
| Basic Insulation Level (Lightening Impulse/Switching Impulse/Power Frequency Withstand Voltage) | | | (a) HV | Kg | |
| HV | kVp/ kVp/ kVrms | | (b) IV | Kg | |
| IV | kVp/ kVp/ kVrms | | (c) LV | Kg | |
| LV | kVp/ kVp/ kVrms | | (d) Regulating | Kg | |
| Neutral | kVp/ kVp/ kVrms | | Core & Coil Mass | Kg | |
| Guaranteed Temperature rise over ambient temperature of 50 Deg. C | | | Transportation Mass | Kg | |
| (a) Top Oil | 0C | | Tank & Fitting mass | | |

| | | | | | |
|---|---|---|---|---|---|
| (b) Winding | 0C | | Type & total mass of insulating oil | Kg | |
| Vacuum withstand Capability of the tank | mm of Hg | | Total mass | Kg | |
| OLTC make and rating (current & Voltage class) | | | Quantity of oil in OLTC | Ltrs | |
| Noise level at rated voltage and at principal tap | dB | | Transformer oil Quantity | Ltrs | |
| Tandelta of winding | | | Paint Shade | | |
| Moisture content | ppm | | No load loss at rated voltage & frequency | KW | |
| Manufacturer's Serial number | | | Load loss at rated current & frequency(at $75^0$C) for HV&IV/ LV winding | KW | |
| Year of manufacture | | | $I^2R$ loss at rated current& frequency (at $75^0$C) for HV&IV/LV winding | KW | |
| Work Order No. | | | Auxiliary loss at rated voltage & frequency | KW | |
| Purchaser's Order No.& Date | | | | | |
| OGA Drg. No. | | | | | |
| Vector Group Diagram | | | | | |
| Winding Connection diagram (Connection between all windings including tap windings, ratings of built-in current transformers, etc., shall be presented on the diagram) | | | | | |
| Table giving details of OLTC like tap position Nos. And corresponding tapping voltage, tapping current & connection between terminals for different tap positions etc. | | | | | |
| Details of Current Transformers (e.g., Bushing CTs, CT for WTI) installed in transformer like the location, core Nos., ratio(s), accuracy class, rated output (VA burden), knee point voltage, magnetizing current, maximum CT secondary resistance, terminal marking and application of the current transformer | | | | | |
| Warning: "Main conservator is fitted with an air cell" | | | | | |
| Tie-in-resistor has been used in OLTC (if applicable) | | | | | |
| **Purchaser's Name** | | | | | |

When a transformer is intended for installation at high altitude, the altitude, power rating and temperature rise at that altitude shall be indicated on the name plate.

Plates with identification and characteristics of auxiliary equipment according to standards for such components (bushings, tap-changers, current transformers, cooling equipment etc.) shall be provided on the components themselves.

**Annexure- G**

**1.0 Technical Parameters of Bushing Current Transformers and Neutral Current Transformers for 200 MVA 220/132 kV 3-Ph Transformers:**

| Description | Bushing Current Transformer Parameters (Transformer) | | |
|---|---|---|---|
| | **HV Side** | **IV Side** | **Neutral Side** |
| **(a) Ratio** | | | |
| CORE 1 | 1000/1 | 1000/1 | 1000/1 |
| CORE 2 | 600/1 | 1000/1 | - |
| CORE 3 | Refer to note 1 | | |
| **(b) Minimum knee point voltage or burden and accuracy class** | | | |
| CORE 1 | 1000V, PX | 1000V, PX | 1000V, PX |
| CORE 2 | 0.2S Class 15VA ISF ≤ 5 | 0.2S Class 15VA ISF ≤ 5 | - |
| CORE 3 | Refer to note 1 | | |
| **(c) Maximum CT Secondary Resistance** | | | |
| CORE 1 | 1.5 Ohm | 1.5 Ohm | 1.5 Ohm |
| CORE 2 | - | - | - |
| CORE 3 | Refer to note 1 | | |
| **(d) Application** | | | |
| CORE 1 | Restricted Earth Fault | Restricted Earth Fault | Restricted Earth Fault |
| CORE 2 | Metering | Metering | - |
| CORE 3 | Refer to note 1 | | |
| **(e) Maximum magnetization current (at knee point voltage)** | | | |
| CORE 1 | 100 mA | 100 mA | 100 mA |
| CORE 2 | - | - | - |
| CORE 3 | Refer to note 1 | | |

NOTE:

i) **Parameters of WTI CT for each winding shall be provided by the contractor.**
ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

**Annexure- H**

**Test Procedures**

**General**

Tests shall be carried out as per following procedure. However, IEC 60076 shall be followed in general for other tests. Manufacturer shall offer the transformer unit for type testing with all major fittings including radiator bank, Marshalling Box, Common Marshalling Box RTCC (as applicable) assembled.

**1. Core assembly dielectric and earthing continuity test**

After assembly each core shall be tested for 1 minute at 2000 Volts between all yoke clamps, side plates and structural steel work (core to frame, frame to tank & core to tank)

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2 kV (DC) for 1 minute. Insulation resistance shall be minimum 1 GΩ for all cases mentioned above.

**2. Measurement of winding resistance**

After the transformer has been under liquid without excitation for at least 3 hr, the average liquid temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average liquid temperature. The average liquid temperature is taken as the mean of the top and bottom liquid temperatures. Measurement of all the windings including compensating (in case terminal is available at outside) at normal and extreme taps

In measuring the cold resistance for the purpose of temperature-rise determination, special efforts shall be made to determine the average winding temperature accurately. Thus, the difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump.

**3. No-load loss and current measurement**

As per IEC 60076-1:2011 clause 11.5

**4. Measurement of short-circuit impedance and load loss**

The short-circuit impedance and load loss for a pair of windings shall be measured at rated current & frequency with voltage applied to the terminals of one winding, with the terminals of the other winding short-circuited, and with possible other windings open- circuited. The difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump. Loss measurement for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps).

**5. Short term heat run test (Not Applicable for unit on which temperature rise test is performed)**

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short-term heat run test to confirm the performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core. DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short-term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short-term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose, the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 CIGRE 1984 SC12-13 paper by Dam, Felber, Preiniger et al.

Short term heat run test may be carried out with the following sequence:

- Heat run test with pumps running but oil not through coolers.

- Raise temperature to 5 deg less than the value measured during temperature rise test.
- Stop power input and pumps for 6 minutes and observe cooling downtrend
- Restart pumps and observe increased cooling trend due to forced oil flow

This test is applicable for the Transformer without Pump also (ONAN or ONAF rating). Forsuchtypeoftransformertestmaybecarriedoutwiththefollowingsequence.

Arrangement shall be required with pump of suitable capacity (considering the oil velocity) without cooler bank. Raise the oil temperature 20-25 deg C above ambient. Stop power input and pumps for 6 minutes and observe cooling down trend. Restart pumps and observe increased cooling trend due to forced oil flow.

**6. Temp. Rise Test as per IEC:60076**

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC60567.

The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) for the Top oil of the transformer.

**3-Winding Loss = HV (Max MVA) + IV (Max MVA) + LV (MaxMVA).**

The Contractor before carrying out such test shall submit detailed calculations showing losses on various taps and for the three types of ratings of the transformer and shall recommend the combination that results in highest temperature rise for the test.

The Temperature rise type test results shall serve as a “finger print” for the units to be tested only with short term heat run test.

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC60567.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC61181.

The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

**i. Test conditions for temperature rise test:**

- This test shall be generally carried out in accordance with IEC60076-2
- For each cooling combination with cooler bank, tests shall be done on the maximum current tap for a minimum of 12 hours for ONAN/ONAF and 24 hours for ODAF or OFAF or ONAF2 with saturated temperature for at least 4 hours while the appropriate power and current for core and load losses are supplied.
- The total testing time, including ONAN heating up period, steady period and winding resistance measurements is expected to be about 48 hours.
- DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

**ii. Test records:**

Full details of the test arrangements, procedures and conditions shall be furnishedwiththetestcertificatesandshallincludeatleastthefollowing

**iii. General:**

- Purchaser’s order number and transformer site designation.
- Manufacturer’s name and transformer serial number.
- Rating of transformer

- MVA
- Voltages and tapping range
- Number of phases
- Frequency
- Rated currents for each winding
- Vector Group
- Cooling Type
- Measured no-load losses and load losses at 75°C.
- Altitude of test bay.
- Designation of terminals supplied and terminals strapped.

**iv. Top oil temperature rise test:**

A log of the following quantities taken at a minimum of 30-minute intervals:

- Time
- Voltage between phases
- Current in each phase and total power
- Power in each phase and total power
- Ambient temperature
- Top oil temperature
- Cooler inlet and outlet oil temperatures
- Hot spot temperatures (make use of probes) (if applicable)
- Colour photographs of the four sides and top of the transformer together with the corresponding series of thermal images (colour) during starting of the test then after every four hours till the temperature stabilised and finally during temperature stabilised for each rating (ONAN/ONAF/OFAF).

**Notes:** The probes may be left in position provided the reliability and integrity of unit will not be jeopardized during its long-life expectancy.

**v. Winding temperature rise test**

- Record the 'cold' resistance of each winding and the simultaneous top oil and ambient air temperatures, together with the time required for the effect to disappear.
- Record the thermal time constant of the winding.
- Log the half-hourly readings of the quantities as for the top oil temperature rise test.
- Provide a table of readings, after shut-down of power, giving the following information;

a) Time after shut-down:
b) Time increment:
c) Winding resistance: At least 20 minutes reading
d) Resistance increment:

- Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.
- Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors (fibre optic) placed at various locations shall also be recorded.

**7. Dielectric Tests**

Following Test shall be performed in the sequence given below as per IEC 60076-3:2013 clause 7.2.3 shall be followed:

a) Lightning impulse tests (LIC, LIN)
b) Switching impulse (SI)
c) Applied voltage test (AV)
d) Line terminal AC withstand test (LTAC)
e) Induced voltage test with partial discharge measurement (IVPD)

**8. Measurement of transferred surge on LV or Tertiary due to HV & IV Lightning impulse:**

Following tests shall be carried out with applying 20% to 80% of rated Impulse & Switching impulse (up to 60% for IV, Sr. No. 7 & 8 of below table) voltage. Finally, measured value shall be extrapolated for 100% rated voltage.

Table for Transfer surge (Impulse) at Max, Nor. and Min. Voltage Tap

| Sr. No. | Impulse Type | Voltage applied | Earthed Points | Open / not earthed point | Measurement Point |
|---|---|---|---|---|---|
| 1 | FW | 1.1 | 2.1, N & 3.2 | - | 3.1 |
| 2 | FW | 1.1 | 2.1, N & 3.1 | - | 3.2 |
| 5 | FW | 2.1 | 1.1, N & 3.2 | - | 3.1 |
| 6 | FW | 2.1 | 1.1, N & 3.1 | - | 3.2 |

Similar tests to be conducted for switching surge transformer at Max, Nor. and Min. Voltage Tap.

Where 1.1 : HV Terminal
2.1 : IV Terminal
3.1&3.2 : LV or Tertiary Terminal

**Acceptance criteria**

Transfer surge at Tertiary should not exceed 250kVp at any conditions for 400kV Voltage class Transformer. For other transformer it shall be below the impulse level of LV winding.

**9. Chopped wave & full wave lightning impulse test for the line terminals (LIC & LI) and switching impulse test**

Chopped wave lightning impulse and switching impulse test shall be performed at normal and extreme taps on Unit-1, Unit-2 and Unit-3 respectively for 1-Ph unit, otherwise R Ph, Y Ph and B Ph respectively for 3-Ph unit. All the parameters as per IEC shall be mentioned in the report.

**10. Measurement of power taken by fans and oil pumps (100 % cooler bank)**

Losses of each fan and pumps including spare shall be measured at rated voltage and frequency. Fans and Pumps shall be mounted with cooler bank as per approved drawing during measurement. Serial No, applied voltage, measured current, frequency and make shall be furnished in the test report.

**11. Tank Tests**

**i. Oil Leakage Test**

All tanks and oil filled compartments shall be completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure equal to normal head of oil plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not lessthan12hoursforoiland1hourforairduringwhichnoleakageshalloccur.

**ii. Vacuum Test**

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

---

**Horizontal Length Permanent deflection of flat plate (in mm)**
**(In mm)**

---

Up to andincluding750 5.0

| | | | |
|---|---|---|---|
| 751 | to | 1250 | 6.5 |
| 1251 | to | 1750 | 8.0 |
| 1751 | to | 2000 | 9.5 |
| 2001 | to | 2250 | 11.0 |
| 2251 | to | 2500 | 12.5 |
| 2501 | to | 3000 | 16.0 |
| Above | | 3000 | 19.0 |

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**iii. Pressure Test**

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

**12.** Dynamic short circuit withstand test shall be carried out as per IEC 60076-5. Dynamic short circuit test shall be carried out in HV-IV combination at nominal & extreme tap positions. For LV winding, dynamic short circuit shall be carried out either on HV-LV or IV-LV combination, whichever draws higher short circuit current as per calculation. Type tests shall be carried out before short circuit test. Following shall also be conducted before and after Short Circuit test:

i) Dissolved gas analysis
ii) Frequency response analysis
iii) All routine tests

Detail test procedure shall be submitted by contractor & shall be approved before short circuit test.

**13.** Routine test on bushings shall be done as per IEC60137.

**Test Plan** **Annexure - I**

| No. | Test | 132≥ Um ≤170kV | $U_m$ > 170kV |
|---|---|---|---|
| 1. | Measurement of winding resistance | Routine | Routine |
| 2. | Voltage ratio measurement | Routine | Routine |
| 3. | Polarity test | Routine | Routine |
| 4. | No-load loss and current measurement | Routine | Routine |
| 5. | Magnetic balance test (for three phase Transformer only) | Routine | Routine |
| 6. | Impedance and load loss measurement | Routine | Routine |
| 7. | Measurement of insulation resistance & Polarization Index | Routine | Routine |
| 8. | Measurement of insulation power factor and capacitance between winding and earth and Bushings | Routine | Routine |
| 9. | Full wave lightning impulse test for the line terminals (LI) | Routine | - |
| 10. | Induced voltage withstand test (IVW) | Routine | - |
| 11. | Applied voltage test (AV) | Routine | Routine |
| 12. | Induced voltage test with PD measurement (IVPD) | Routine | Routine |
| 13. | On-load tap changer test (Ten complete cycle before LV test) | Routine | Routine |
| 14. | Gas-in-oil analysis | Routine | Routine |
| 15. | Core assembly dielectric and earthing continuity test | Routine | Routine |
| 16. | Oil leakage test on transformer tank | Routine | Routine |
| 17. | Appearance, construction and dimension check | Routine | Routine |
| 18. | Short duration heat run test (Not Applicable for unit on which temperature rise test is performed) | Routine | Routine |
| 19. | Measurement of no load current & Short circuit Impedance with415 V, 50 Hz AC. | Routine | Routine |
| 20 | Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports) | Routine | Routine |
| 21. | High voltage with stand test on auxiliary equipment and wiring after assembly | Routine | Routine |
| 22. | Tank vacuum test | Routine | Routine |
| 23. | Tank pressure test | Routine | Routine |
| 24. | Chopped wave lightning impulse test for the line terminals (LIC) | Type | Routine |
| 25. | Switching impulse test for the line terminal (SI) | Type | Routine |
| 26 | Line terminal AC withstand voltage test (LTAC) | Routine | Type |
| 27. | Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable) | Type | Type |
| 28. | Lightning impulse test for the neutral terminals (LIN) | Type | Type |
| 29. | Temperature rise test | Type | Type |
| 30. | Measurement of Zero seq. reactance (For three phase Transformer only) | Type | Type |
| 31. | Measurement of harmonic level in no load current | Type | Type |
| 32. | Measurement of acoustic noise level | Type | Type |
| 33. | Measurement of power taken by fans and oil pumps (Not applicable for ONAN) | Type | Type |
| 34. | Dynamic Short circuit withstand test | Type | Type |

**ANNEXURE J**

**PT 100 Resistance (Temperature Vs Resistance)**
**(BS 1904: 1984 & IEC 751: 1985)**

| TEMP °C | RESISTANCE (OHMS) | | |
|---|---|---|---|
| | LOW | NOMINAL | HIGH |
| 0 | 99.88 | 100.00 | 100.12 |
| 10 | 103.76 | 103.90 | 104.04 |
| 20 | 107.63 | 107.79 | 107.95 |
| 30 | 111.49 | 111.67 | 111.85 |
| 40 | 115.35 | 115.54 | 115.73 |
| 50 | 119.19 | 119.40 | 119.61 |
| 60 | 123.01 | 123.24 | 123.47 |
| 70 | 126.82 | 127.07 | 127.32 |
| 80 | 130.62 | 130.89 | 131.16 |
| 90 | 134.42 | 134.70 | 134.98 |
| 100 | 138.20 | 138.50 | 138.80 |
| 110 | 141.97 | 142.29 | 142.61 |
| 120 | 145.72 | 146.06 | 146.40 |
| 130 | 149.46 | 149.82 | 150.18 |
| 140 | 153.21 | 153.58 | 153.95 |
| 150 | 156.92 | 157.31 | 157.70 |

**PT 100 (Temperature Vs Output Signal)**
**TemperatureRange:0-150$^{O}$c**
**Signal Range: 4-20 mA**

| TEMPERATURE °C | NOMINAL RESISTANCE (OHMS) | OUTPUT SIGNAL RANGE (4 - 20mA) | | |
|---|---|---|---|---|
| | | LOW | NOMINAL | HIGH |
| 0 | 100.00 | 3.800 | 4.000 | 4.200 |
| 10 | 103.90 | 4.867 | 5.067 | 5.267 |
| 20 | 107.79 | 5.933 | 6.133 | 6.333 |
| 30 | 111.67 | 7.000 | 7.200 | 7.400 |
| 40 | 115.54 | 8.066 | 8.266 | 8.466 |
| 50 | 119.40 | 9.133 | 9.333 | 9.533 |
| 60 | 123.24 | 10.200 | 10.400 | 10.600 |
| 70 | 127.07 | 11.266 | 11.466 | 11.666 |
| 80 | 130.89 | 12.333 | 12.533 | 12.733 |
| 90 | 134.70 | 13.399 | 13.599 | 13.799 |
| 100 | 138.50 | 14.466 | 14.666 | 14.866 |
| 110 | 142.29 | 15.533 | 15.733 | 15.933 |
| 120 | 146.06 | 16.599 | 16.799 | 16.999 |
| 130 | 149.82 | 17.666 | 17.866 | 18.066 |
| 140 | 153.58 | 18.732 | 18.932 | 19.132 |
| 150 | 157.31 | 19.800 | 20.000 | 20.200 |

**ANNEXURE - K**

**Online Dissolved Gas (Multi-gas) and Moisture Analyser**

**1.1.** Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each Transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC60599-1999.

**1.2.** The equipment shall detect, measure and analyse the following gases:

| Gases & Moisture Parameters | Typical Detection Range |
|---|---|
| $H_2$ | 5 – 5,000 ppm |
| $CH_4$ | 5 – 5,000 ppm |
| $C_2H_6$ | 5 – 5,000 ppm |
| $C_2H_4$ | 3 – 5,000 ppm |
| $C_2H_2$ | 1 – 3,000 ppm |
| CO | 10 – 10,000 ppm |
| $CO_2$ | 20 – 30,000 ppm |
| $H_2O$ | 2 – 100 % RS should have facility for measurement of moisture in oil in ppm |

**1.3.** The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

**1.4.** Equipment shall have facility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

**1.5.** Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

**1.6.** Online DGA shall be installed out door on Transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless-Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55 $^0$C ambient temperature and EMI and EMC compatibility. The Equipment must carry a minimum of five (5) years manufacturer's Warranty.

**1.7.** The equipment shall display all the individual gas and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. The carrier and calibration gas (if applicable) shall have minimum capacity to work for atleast three years without replacement. All the consumable (if any) up to warrantee period shall be included in the scope of supply.

**1.8.** The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

**1.9.** The technical feature of the equipment shall be asunder:

| | |
|---|---|
| Accuracy | + 10% |
| Repeatability | +3% to 10% depending upon gases |
| Oil temperature range | - $20^0$ C to + $120^0$ C |
| External Temp. Range | - $20^0$ C to + $55^0$ C<br>(External temp range of $55^0$ C is important and should not be compromise due to Indian ambient & operating conditions.) |
| Humidity range | 10 to 95 % |
| Operating Voltage | 230 Vac; 50 Hz (±20% variation) |
| Communications | USB&IEC 61850 compliant |

**1.10.** Software for fault indication and fault diagnostics shall include following:
Fault indication:
i. IEEE, IEC or user configurable levels of dissolved gases
ii. Rate of change trending

Fault Diagnosis:
i. Key gases
ii. Ratios (Rogers, IEC, etc.)
iii. Duval's Triangle

**1.11.** The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also forming a part of supply.
i) Software,
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

**1.12.** The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

**1.13.** The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test setup. During this period, if the kit needs to be shifted to supplier's works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

**Annexure – L**

**LIST OF TESTING EQUIPMENT**

| Sr. No. | Testing Equipment | Make & Model * |
|---|---|---|
| 1 | Oil Storage Tank (With Wheels)- 20kL Capacity | VPI / CEE DEE VACUUM / SICORP |
| 2 | Stainless Steel Oil sampling bottle (One Litre Capacity) | SCIENO TECH 1 litre |
| 3 | Syringes for sampling oil | Tomopol (Industrial Grade) |

**** Bidder may offer equivalent or superior testing equipment.***

**ANNEXURE - M**

## 1.1 KV GRADE POWER & CONTROL CABLES

1.1 All Power & Control cables shall be supplied from reputed vendors.

1.2 Separate cables shall be used for AC & DC.

1.3 Separate cables shall be used for DC1 & DC2.

1.4 At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.5 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All aluminium used in the cables shall be of H2 grade.

1.6 The fillers and inner sheath shall be of non-hygroscopic, fire-retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.7 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.8 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.9 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.10 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

1.11 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

1.12 Repaired cables shall not be accepted.

1.13 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.14 **PVC Power Cables**

1.14.1 The PVC (70°C) insulated 1100V grade power cables s hall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS: 5831 for all cables. The contractor can used copper cable of required size.

1.15 **PVC Control Cables**

1.15.1 The 1100V grade control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the Employer to be black.

1.15.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS: 1554 (Part - 1).

## STANDARD TECHNICAL DATASHEET (1.1KV GRADE XLPE POWER CABLES)

| Sl. No | Description | Parameters | |
|---|---|---|---|
| 1a | Cable Sizes | 1 C x 630 | 3½ C x300 |
| b | Manufacturer's type designation | A2XWaY | A2XWY |
| 2 | Applicable standard | IS:7098/PT-I/1988&itsreferred specifications | |
| 3 | Rated Voltage(volts) | 1100VGrade | |
| 4 | Type & Category | FR&C1 | FR&C1 |
| 5 | Suitable for earthed or unearthed system | for both | |
| 6 | Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of70°C of PVC Cables [For information only] | 732 | 410 |
| 7 | Rating factors applicable to the current ratings for various conditions of installation | AsperIS-3961-Pt-II-67 | |
| 8 | Short circuit Capacity | | |
| a | Guaranteed Short Circuit Amp.(rms) KA for 0.12 sec duration at rated conductor temperature of 90 degree C, with an initial peak of 105KA | 45kA | 45kA |
| b | Maximum Conductor temp. allowed for the short circuit duty(degC.) as stated above | 250°C | |
| 9 | Conductor | | |
| a | Material | Stranded Aluminium as perClass2 of IS : 8130 | |
| b | Grade | H2(Electrolytic grade) | |
| c | Cross Section area(Sq.mm.) | 630 | 300/150 |
| d | Number of wires (No.) minimum | 53 | 30/15 |
| e | Form of Conductor | Stranded and compacted circular | Stranded compacted circular/sector shaped |
| f | Direction of lay of stranded layers | Outer most layer shall be R.H lay & opposite In successive layers | |
| 10 | Conductor resistance (DC)at20°Cperkm-maximum | 0.0469 | 0.1/0.206 |
| 11 | Insulation | | |
| a | Composition of insulation | Extruded XLPE as perIS-7098 Part(1) | |
| b | Nominal thickness of insulation(mm) | 2.8 | 1.8/1.4 |
| c | Minimum thickness of insulation | 2.42 | 1.52/1.16 |
| 12 | Inner Sheath | | |
| a | Material | ExtrudedPVCtypeST-2asper IS-5831-84 | |
| b | Calculated diameter over the laid-up cores, (mm) | NA | 52 |
| c | Thickness of Sheath(minimum)mm | NA | 0.6 |
| d | Method of extrusion | NA | Pressure/Vacuum extrusion |
| 13 | Armour | | |
| a | Type and material of armour | Al wire[H4grade] | Gal. Steel wire |
| b | Direction of armouring | Left hand | |

| | | | |
|---|---|---|---|
| c | Calculated diameter of cable over inner sheath (under armour),mm | 33.9 | 53.2 |
| d | Nominal diameter of round armour wire(minimum) | 2 | 2.5 |
| e | Guaranteed Short circuit capacity of the armour for 0.12secatroomtemperature | 45kA | 45kA |
| f | DC resistance at 20 °C(Ω/Km) | $ | 0.577 |
| 14 | Outer Sheath | ST-2 & FR | ST-2 & FR |
| a | Material (PVC Type) | 38.3 | 59.50 |
| b | Calculated diameter under the sheath | 1.72 | 2.36 |
| c | Min. thickness of sheath(mm) | Min 29.0 | Min 29.0 |
| d | Guaranteed value of minimum oxygen index of outer sheath at 27 o C | Min 250 | Min 250 |
| e | Guaranteed value of minimum temperature index at 21 oxygen index | $ | $ |
| f | colour of sheath | Black | Black |
| 15a | Nominal Overall diameter of cable | +2/-2mm | |
| b | Tolerance on overall diameter(mm) | shall conform to IS 10418andtechnical specification | |
| 16 | Cable Drums | 1000/500 | 1000/500 |
| a | Max./Standard length per drum for each size of cable (single length) with±5%Tolerance(mtrs) | | |
| b | Non-standard drum lengths | Maximum one (1) non-standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above. (If required for completion of project) | |
| 17 | Whether progressive sequential marking on outer sheath provided at1 meterinterval18 | Yes | |
| 18 | Identification of cores | | |
| a | Colour of cores | AsperIS7098Part (1) | |
| b | Numbering | NA | |
| 19 | Whether Cables offered are ISI marked | Yes | |
| 20 | Whether Cables offered are suitable for laying as per IS 1255 | Yes | |

**$'-As per manufacturer design data**

**STANDARD TECHNICAL DATA SHEET-1.1 KV GRADE PVC POWER CABLES**

| SN | Description | Parameters | | | | | |
|---|---|---|---|---|---|---|---|
| 1a | Cable Sizes | 1 cx 150 | 3.5 cx 70 | 3.5 cx 35 | 4 c x16 | 4c x 6 | 2 c x6 |
| 1b | Manufacturer's type designation | AYWaY | AYFY | AYFY | AYFY | AYWY | AYWY |
| 2 | Applicable standard | IS:1554/PT-I/1988&itsreferredstandards | | | | | |
| 3 | Rated Voltage(volts) | 1100Vgrade | | | | | |
| 4 | Type & Category | FR& C1 | FR& C1 | FR& C1 | FR& C1 | FR& C1 | FR& C1 |
| 5 | Suitable for earthed or unearthed system | for both | | | | | |
| 6 | Continuous current rating when lay in air in an ambient temp. of50oC and for maximum conductor temp.of 70deg Cof PVC Cables[For information only] | 202 | 105 | 70 | 41 | 24 | 28 |
| 7 | Rating factors applicable to the current ratings for various conditions of installation: | AsperIS-3961-Pt-II-67 | | | | | |
| 8 | Short circuit Capacity | | | | | | |
| a) | Short Circuit Amp.(rms)KAfor1 sec duration | 11.2 | 5.22 | 2.61 | 1.19 | 0.448 | 0.448 |
| b) | Conductor temp.allowed for the short circuit duty(degC.) | $160^0$C | | | | | |
| 9 | Conductor | | | | | | |
| a) | Material | STRANDEDALUMINIUM | | | | | |
| b) | Grade | H2(Electrolytic grade) | | | | | |
| c) | Cross Section area (Sq.mm.) | 150 | M-70 N-35 | M-35 N-16 | 16 | 6 | 6 |
| d) | Number of wires (No.) | asperTable2of IS 8130 | | | | | |
| e) | Form of Conductor | Non-compacted Stranded circular | shaped conductor | shaped conductor | shaped conductor | Non-compacted Stranded circular | Non-compacted Stranded circular |
| f) | Direction of lay of stranded layers | Outer most layer shall be R.Hlay & opposite in successive layer | | | | | |
| 10 | Conductor resistance (DC) at 20oCperkm-maximum | 0.206 | 0.443/0.868 | 0.868/1.91 | 1.91 | 4.61 | 4.61 |
| 11 | Insulation | | | | | | |
| a) | Composition of insulation | Extruded PVC type A as per IS-5831-84 | | | | | |
| b) | Nominal thickness of insulation(mm) | 2.1 | 1.4/1.2 | 1.2/1.0 | 1.0 | 1.0 | 1.0 |
| c) | Minimum thickness of insulation | 1.79 | 1.16/0.98 | 0.98/0.8 | 0.8 | 0.8 | 0.8 |
| 12 | Inner Sheath | | | | | | |
| a) | Material | Extruded PVC type ST-lasper IS-5831-84 | | | | | |
| b) | Calculated diameter over the laid up cores,(mm) | N.A | 27.6 | 20.4 | 15.7 | 11.6 | 9.6 |
| c) | Thickness of Sheath(minimum) mm | N.A | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | Armour | asper IS3975/88 | | | | | |
| a) | a) Type and material of armour | Al. Wire[H 4grade] | Gal. steel strip | Gal. steel strip | Gal. steel strip | Gal.steel wire | Gal. Steel wire |
| b) | b) Direction of armouring | left-hand | | | | | |
| c) | c) Calculated diameter of cable over inner sheath (under armour),mm | 18 | 28.4 | 21 | 16.3 | 12.2 | 10.2 |
| d) | d)Nominal diameter of round armour wire/strip | 1.6 4 | 0.8 4 | 0.8 4 | 0.8 | 1.4 | 1.4 |
| e) | e) Number of armour wires/strips | Armouring shall be as close as practicable | | | | | |
| f) | f) Short circuit capacity of the armour along for 1 sec-for info only | Kx A√t(KAmp) (where A=total area of armourin $mm^2$&t=time in seconds),K=0.091forAl&0.05forsteel | | | | | |
| g) | g) DC resistance at 20°C(Ω/Km) | 0.44 | 2.57 | 3.38 4 | 3.99 | 3.76 | 4.4 |
| 14 | Outer Sheath | | | | | | |
| a) | a) Material (PVC Type) | ST-1&FR | ST-1&FR | ST-1&FR | ST-1&FR | ST-1&FR | ST-1&FR |
| b) | b) Calculated diameter under the sheath | 21.2 | 30.1 | 22.6 | 17.9 | 15 | 13 |
| c) | c)Min. thickness of sheath(mm) | 1.4 | 1.56 | 1.4 | 1.4 | 1.4 | 1.24 |
| d) | d)Guaranteed value of minimum oxygen index of outer sheath at27oC | Min2 9.0 | Min2 9.0 | Min2 9.0 | Min 29.0 | Min2 9.0 | Min2 9.0 |
| e) | e) Guaranteed value of minimum temperatureindexat21oxygenindex | Min2 50 | Min2 50 | Min2 50 | Min 250 | Min2 50 | Min250 |
| f) | f) colour of sheath | Black | Black | Black | Black | Black | Black |
| 15a) | a) Overall diameter of cable | $ | | | | | |
| b) | b) Tolerance on overall diameter (mm) | +2/-2mm | | | | | |
| 16 | Cable Drums | Shall conform to IS10418 and technical specification | | | | | |
| a) | a) Max./ Standard length per drum for each size of cable (single length) with±5%Tolerance(mtrs) | 1000/50 0 | 1000/50 0 | 1000/5 00 | 1000/50 0 | 1000/50 0 | 1000/50 0 |
| b) | b) Nonstandard drum lengths | Maximum one(1) nonstandard lengths of each cable size may be supplied in drums only over& above the standard lengths as specified above.(if required for completion of project) | | | | | |
| 17 | Whether progressive sequential marking on outer sheath provided | Yes | | | | | |
| 18 | Identification of cores | | | | | | |
| a) | a) colour of cores | Red | R,Y,Bl &Bk | R,Y,B l&Bk | R,Y,Bl &Bk | R,Y,Bl &Bk | Red& Bk |
| b) | b) Numbering | N.A | N.A | N.A | N.A | N.A | N.A |
| 19 | Whether Cables offered are ISI marked | YES | | | | | |
| 20 | Whether Cables offered are suitable for laying as per IS 1255 | YES | | | | | |

**$'-Aspermanufacturerdesign data**

**STANDARD TECHNICAL DATA SHEET-1.1 KV GRADE PVC CONTROL CABLES**

| Sl. No | Description | Parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1a | Cable Sizes | 2 cx 2.5 | 3ccx2 .5 | 5c x2.5 | 7 cx 2.5 | 10 cx 2.5 | 14 cx 2.5 | 19 c x2.5 | 27 cx 2.5 |
| 1b | Manufacturer's type designation | YWY | YWY | YWY | YWY | YWY | YWY | YWY | YWY |
| 2 | Applicable standard | IS:1554/PT-I/1988&its referred standards | | | | | | | |
| 3 | Rated Voltage(volts) | 1100Vgrade | | | | | | | |
| 4 | Type &Category | FR&C1 | | | | | | | |
| 5 | Suitable for earthed or unearthed system | for both | | | | | | | |
| 6 | Continuous current rating when laid in air in a ambient temp. of 50oCand for maximum conductor temp. of70 oC of PVC Cables [For information only] | 22 | 19 | 19 | 14 | 12 | 10.5 | 9.7 | 8 |
| 7 | Rating factors applicable to the current ratings for various conditions of installation: | AsperIS-3961-Pt-II-67 | | | | | | | |
| 8 | Short circuit Capacity | | | | | | | | |
| a) | Short Circuit Amp. (rms)KAfor1secdurati on | 0.285 | 0.285 | 0.285 | 0.285 | 0.285 | 0.285 | 0.285 | 0.285 |
| b) | Conductor temp.allowed for the short circuit duty(degC.) | $160^0$C | | | | | | | |
| 9 | Conductor | | | | | | | | |
| a) | Material | Plain annealed High Conductivity stranded Copper (as per IS8130/84) | | | | | | | |
| b) | Grade | Electrolytic | | | | | | | |
| c) | Cross Section area (Sq.mm.) | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| d) | Number of wires (No.) | asperTable2of IS 8130 | | | | | | | |
| e) | Form of Conductor | Non-compacted Stranded circular shaped conductor | | | | | | | |
| f) | Direction of lay of stranded layers | Outer most layer shall be R.Hlay | | | | | | | |
| 10 | Conductor resistance (DC)at20oCperkm-maximum | 7.41 | 7.41 | 7.41 | 7.41 | 7.41 | 7.41 | 7.41 | 7.41 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 11 | Insulation | | | | | | | | |
| a) | Composition of insulation | Extruded PVC type A as per IS-5831-84 | | | | | | | |
| b) | Nominal thickness of insulation(mm) | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| c) | Minimum thickness of insulation | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 |
| 12 | Inner Sheath | | | | | | | | |
| a) | Material | Extruded PVC type ST-lasper IS-5831-84 | | | | | | | |
| b) | Calculated diameter over the laid up cores,(mm) | 7.2 | 7.8 | 9.7 | 10.8 | 14.4 | 15.9 | 18 | 22.1 |
| c) | Thickness of Sheath (minimum)mm | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| 13 | Armour | as per IS3975/99 | | | | | | | |
| a) | Type and material of armour | Gal. Steel Wire | | | | | | | |
| b) | Direction of armouring | left hand | | | | | | | |
| c) | Calculated diameter of cable over inner sheath (under armour), mm | 7.8 | 8.4 | 10.3 | 11.4 | 15 | 6.5 | 18.6 | 22.7 |
| d) | Nominal diameter of round armour wire/strip | 1.4 | 1.4 | 1.4 | 1.4 | 1.6 | 1.6 | 1.6 | 1.6 |
| e) | Number of armour wires/strips | Armouring shall be as close as practicable | | | | | | | |
| f) | Short circuit capacity of thearmouralongfor1sec-for info only | 0.05xA√t(KAmp)(whereA=total area of armouring mm2 &t =time in seconds) | | | | | | | |
| g) | DCresistanceat20oC(Ω/Km )&Resistivity | As per IS 1554Part(1),wherever applicable and IS3975-1999 | | | | | | | |
| 14 | Outer Sheath | | | | | | | | |
| a) | Material (PVC Type) | ST-1&FR | | | | | | | |
| b) | Calculated diameter under the sheath | 10.6 | 11.2 | 13.1 | 14.2 | 18.2 | 19.7 | 21.8 | 25.9 |
| c) | Min. thickness of sheath(mm) | 1.24 | 1.24 | 1.24 | 1.24 | 1.4 | 1.4 | 1.4 | 1.56 |
| d) | Guaranteed value of minimum oxygen index of outer sheath at27oC | Min2 9.0 | Min2 9.0 | Min2 9.0 | Min2 9.0 | Min2 9.0 | Min2 9.0 | Min2 9.0 | Min2 9.0 |
| e) | Guaranteed value of minimum temperature index at21oxygenindex | Min2 50 | Min2 50 | Min2 50 | Min2 50 | Min2 50 | Min2 50 | Min2 50 | Min2 50 |
| f) | colour of sheath | Grey | Grey | Grey | Grey | Grey | Grey | Grey | Grey |
| 15a) | Overall diameter of cable | $ | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| b) | Tolerance on overall diameter(mm) | +2/-2mm | | | | | | |
| 16 | Cable Drums | Shall conform to IS10418 and technical specification | | | | | | |
| a) | Max./ Standard length per drum for each size of cable (single length) with±5%Tolerance(mtr) | 1000/500 | | | | | | |
| **b)** | Nonstandard drum lengths | **Maximum one(1) nonstandard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)** | | | | | | |
| 17 | Whether progressive sequential marking on outer sheath provided | | | | | | | |
| 18 | Identification of cores | Yes | | | | | | |
| a) | colour of cores | R &Bk | R,Y &Bl | RedR, Y,Bl | Grey | Grey | Grey | Grey | Grey |
| b) | Numbering | N.A | N.A | N.A | Numerals in black ink | | | |
| 19 | Whether Cables offered are ISI marked | YES | | | | | | |
| 20 | Whether Cables offered are suitable for laying as per IS 1255 | YES | | | | | | |

**$'-As per manufacturer design data**

**ANNEXURE-N**

## On Line Dissolved Hydrogen and Moisture Monitor

1.0 Online Dissolved Hydrogen and Moisture Analyser along with all required accessories including in built display shall be provided with each Transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC60599-1999

2.0 The equipment shall be capable of transferring data to sub-station automation system confirming to IEC61850.Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering

3.0 Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier

4.0 Equipment shall be installed out door on Transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless-Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steel enclosure, suitable for 55 $^0$C ambient temperature and EMI and EMC compatibility. The Equipment must carry a minimum of five (5) years manufacturer's Warranty

5.0 The equipment shall display $H_2$ and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have in built memory to store these results for complete one year even if sampling is done at the lowest interval. All the consumable (if any) up to warrantee period shall be included in the scope of supply

6.0 The monitor shall also be suitable to detect Water Content measured in ppm or % RS (Relative Saturation). The sensors shall be able to withstand pressure from vacuum to 10 psi.

7.0 Technical Parameters:

| Sr. No. | Parameters | Requirements |
|---|---|---|
| a) | The measurement range / Output: | |
| | Hydrogen Dissolved in oil | 0 to 2000 ppm, with 4 – 20 mA output |
| | Water Dissolved in oil | 0 to 95% RS, with 4 – 20 mA output |
| b) | Alarms/Indication (High & Very High) | |
| | Hydrogen | Programmable NO/NC contacts, |
| | Water | Programmable NO/NC contacts, |
| c) | Environment | |
| | Operating Ambient Temperature | – 20 to + 55 degC |
| | Operating Oil Temperature | – 20 to + 105 degC |
| d) | Pressure Withstand, (Oil side) | Full Vacuum to 10 psi. |
| e) | Communications | USB&IEC 61850 compliant |

Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided support and protect the inlet and outlet piping arrangement.

8.0 Software for fault indication and fault diagnostics shall include following:

i. Fault indication

ii. IEEE, IEC or user configurable levels of dissolved gases
iii. Rate of change trending

9.0The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall also form a part of supply:

Software

i. Operation Manual (2 set for every unit),
ii. Software Manual and
iii. Compact disc giving operation procedures of Maintenance Manual &Trouble shooting instructions

10.0 The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

11.0The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to supplier's works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

**ANNEXURE - O**

## On-line insulating oil drying system (Cartridge type)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each Transformer shall be provided with an on-line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This on-line insulating oil drying system shall be:

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5LPM).

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air / contamination is trapped during commissioning.

iv. In case, drying system is transported with oil, the oil shall conform to EMPLOYER specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.

v. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on-line insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

vi. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

vii. Theequipmentshallbecapableoftransferringdatatosubstationautomation system confirming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the contractor for integration with automation system.

viii. The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test setup. During this period, if the kit needs to be shifted to supplier's works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works.

ix. The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

**ANNEXURE - P**

## Nitrogen Injection Type Fire Prevention & Extinguishing System

**1.** Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer tank and the fire during internal faults/arc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a pre- determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e., core coil assembly).

Electrical isolation of transformer shall be an essential pre-condition for activating the system.

**2.** Operational Controls

The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

**2.1** Prevention of transformer from explosion and fire

To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays (Differential / Restricted earth fault) and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

**2.2** Prevention of transformer from fire in case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

**3.** Operation of System

On receiving activation signal, the following shall take place:

i) Open the quick opening drain valve to drain the top layer oil

ii) Shutofftheconservatorisolationvalvetopreventflowofoilfromthe Conservatortankto the main tank

iii) Open the valve to inject Nitrogen into the transformer tank to create stirring of oil.

There shall be interlock to prevent activation of the system if the transformer is not electrically isolated.

There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

**4.** Technical Particulars

The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from AEGCL.

Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor's responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box: -

- Nitrogen cylinder pressure indication-manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer
- Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

**5.** Details of Supply of System Equipment and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble-free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:

- Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
- Oil Drain Assembly including oil drainpipe extension of suitable size for connecting pipes to oil pit
- Mechanical release device for oil drain and nitrogen release
- Limit switches for monitoring of the systems
- Panel lighting
- Flangesontopofthepanelforconnectingoildrainandnitrogeninjectionpipes for transformer
- Back up pressure switch to operate nitrogen gas valve
- Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator
- Fire Extinguishing Cubicle shall have oil leakage detection arrangement for detecting oil leakage from drain valve. In case of any oil leakages, alarm to be provided.
- shall have minimum IP55 degree of protection

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signaling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering. Fire detectors shall have minimum IP-67 class degree of protection.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

v) Flow sensitive conservator Isolation valve to isolate the conservator oil from the main tank is being provided by the transformer supplier. This valve shall be located in the piping between the conservator and the buchholz relay.

**6.** Under Ground Oil Storage Tank

Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have non-Corrosive, waterproof, epoxy coated (from Inside) mild steel (minimum thickness 5mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **table below:**

| Painting | Surface preparation | Primer coat | Intermediate undercoat | Finish coat | Total dry film thick-ness (DFT) | Colour shade |
|---|---|---|---|---|---|---|
| Oil Storage Tank | Shot Blast cleaning Sa 2 ½* | Epoxy base Zinc primer (30-40□m) | Epoxy high build Micaceous iron oxide (HB MIO) (75□m) | Aliphatic polyurethane (PU) (Minimum 50□m) | Minimum 155□m | RAL 7035 |

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rainwater. The design of tank and pit shall be finalised during detailed engineering.

**7.** The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the system.

**8.** Installation and pre-commissioning test: After installation the system pre-commissioning tests shall be carried out jointly with the Owner's representative before the system is put in-service.

**ANNEXURE-Q**

## Oil sampling bottles

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from Transformers and shunt Reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

The scope of oil sampling bottles shall be included in the bid price as per the quantity indicated in the bid price schedule.

## Oil Syringe

If specified in BPS, the glass syringe of capacity 50ml (approx.) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC- 60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient fingertip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.

**ANNEXURE - R**

## Oil Storage Tank

1. Oil storage tank shall be of minimum capacity (as per BPS) along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g., IS 10987 (1992) or BS 2594. Transformer oil storage tanks **shall be towable on pneumatic tyres** and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of thickness as per standard. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100 deg C.
2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.
3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.
4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horsepower to pull one tank completely filled with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.
5. Each tank shall be thoroughly cleaned internally of all loose matter and then tested to a pressure of 0.7 bar, measured at the top of the tank as per standard. Tank shall also be tested at internal vacuum of 10mbar.
6. The following accessories shall also form part of supply along with each Oil storage tank.

7.1 Four numbers of 50NB suitable rubber hoses for Transformer oil application upto temperature of 100 deg. C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

7.2 Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

7.3 One number of digital vacuum gauge with sensor capable of reading upto 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with at-least 8-meter cable so as to suitably place the Vacuum gauge at ground level.

7.4 The painting of oil storage tank and its control panel shall be as per technical specification.

7.5 The tank shall contain a self-mounted centrifugal oil pump with inlet and outlet valves, with couplers-suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55enclosure.

**ANNEXURE – S**

**Condition Controlled Maintenance Free Type Breather**

**1.** The main Transformer tank conservator shall be fitted with a Maintenance-Free type silica gel Breather which shall be equipped with a microprocessor control unit and LED status indication.

**2.** Dehydrating breather's operating principle:

When the oil conservator breaths-in (e.g., at reduced load), the air flows through a filter made of high-grade steel wire mesh. The equipment fitted with filter & the dust cap, filters the dust, sand and other dirt particles from the air. The filtered air flows through the desiccant chamber filled with colorless, moisture adsorbing pellets and are dehydrated. The dehydrated air rises further via the pipe in the oil conservator. The desiccant is dehydrated by the built-in heating unit which is controlled by sensors, thus obviating the need for periodic desiccant replacement. The dehydrating breather is mounted on the pipe to the oil conservator at a height of 1200 mm approximately from transformer rail top level.

**3.** Technical Features:

**3.1** Material & External Construction of the Breather shall be such that all external parts are suitable for outdoor use & resistive to transformer oil, ultraviolet rays, pollution & salt water and shall work without any trouble for ambient temperature between 0o C to +80oC.

**3.2** Following LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:

a) LED for Power of control unit -ON
b) LED for Filter heater-ON
c) LED for Anti-condensation heater (of control unit) -ON
d) LED & relay contact for "Device Error"
e) LED & relay contact for Regeneration active (De-humidification in process)
f) Analogue output signal (4-20mA) for the Temperature of air (in filter unit / pipe).

**3.3** The Breather shall be equipped with test button which should allow to carry out a self-test and to check the functions like relay circuits, heating or the signal transmission in the control room, etc. at anytime.

**3.4** Control unit shall be equipped with a communication port for downloading the operational data logged by the unit. All necessary software required for downloading and analysing the logger data shall also be provided by the supplier. Supply of Laptop/PC for above software is not envisaged.

**3.5** The moisture and temperature measurement system (sensor) installed should be modular making it easy to replace the same if at all the same is necessary during the service of breather.

**3.6** The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied with the equipment.

**3.7** Degree of Protection shall be at least IP55 for which type Test report shall be submitted. Necessary protective devices shall be provided in order to protect the equipment against over voltages & high-frequency interference.

**3.8** The control unit shall be equipped with suitable heater to prevent moisture condensation.

**3.9** The size of Condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.

**4.** The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over. During this period, if the equipment needs to be shifted to supplier's works for repairs, supplier will have to bear the cost of, spares, software, and transportation etc. of this equipment for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

**5.** Condition Controlled Maintenance Free Type Breather of alternate proven technology shall also be acceptable.

**Annexure-T**

**LIST OF CODES/STANDARDS/REGULATIONS/PUBLICATIONS**

A list of Codes/Standards/Regulations/Publications which shall be used for design review, manufacturing, testing, erection, transportation etc. has been given below. In case of revision/amendment of these, revised/amended versions shall be followed.

| | | |
|---|---|---|
| IS2026:Part1:2011 (ReaffirmedYear:2016) | - | Power transformers: Part 1 General |
| IS2026:Part2:2010 (ReaffirmedYear:2020) | - | Power transformers Part 2 Temperature-rise |
| IS2026:Part3:2018 | - | Power Transformers Part 3 Insulation Levels, Dielectric Tests and External Clearances in Air (Fourth Revision) |
| IS2026:Part4:1977 (ReaffirmedYear:2016) | - | Power transformers: Part 4 Terminal marking, tappings and connections |
| IS2026:Part5:2011 (ReaffirmedYear:2016) | - | Power Transformers Part 5 Ability to Withstand Short Circuit |
| IS2026:Part6:2017 | - | Power Transformers Part 6 Reactors |
| IS2026:PART7:2009 (ReaffirmedYear:2019) | - | Power Transformers Part 7 Loading Guide for Oil-Immersed Power Transformers |
| IS2026:Part8:2009 (ReaffirmedYear:2019) | - | Power Transformers: Part 8 Applications guide |
| IS2026:Part10:2009 (ReaffirmedYear:2019) | - | Power Transformers: Part 10 Determination of sound levels |
| IS2026:Part10: Sec1: 2018 | - | Power Transformers part 10 Determination of Sound Levels Section 1 Application guide |
| IS2026:Part14:2018 | - | Power Transformers Part 14 Liquid-Immersed Power Transformers Using High-Temperature Insulation Materials |
| IS2026:Part18:2018 | - | Power Transformers Part18 Measurement of Frequency Response |
| IEC 60076 All parts | - | Power Transformers |
| IS 3024: 2015 | - | Grain Oriented Electrical Steel Sheet and Strip (Third Revision) |
| IS 8468: Part 1: 2018 IEC 60214-1: 2014 | - | Tap-Changers Part 1 Performance Requirements and Test Methods (First Revision) |
| IEC / IEEE 60214- 2:2019 | | Tap-changers- Part 2: Application guidelines |
| IS 8478: 1977 (Reaffirmed Year: 2016) | - | Application guide for on-load tap changers |
| IS 649: 1997 (Reaffirmed Year: 2018) | - | Methods for testing steel sheets for magnetic circuits of power electrical apparatus |
| IS-10028 (Part 1, 2 & 3) | - | Code of practice for selection, installation & maintenance of transformer |
| IS 3639: 1966 (Reaffirmed Year: 2016) | - | Fittings and Accessories for Power Transformers |
| IS 3637: 1966 (Reaffirmed Year: 2016) | - | Gas Operated Relays |

| | | |
|---|---|---|
| IS 335: 2018 | - | New Insulating Oils — Specification (Fifth Revision) |
| IEC 60296-2020 | - | Fluids for electro technical applications – Mineral insulating oils for electrical equipment |
| IEC 60422: 2013 | - | Mineral insulating oils in electrical equipment - Supervision and maintenance guidance |
| IS 6792: 2017 | - | Insulating Liquids - Determination of the Breakdown Voltage at Power Frequency - Test Method (Second Revision) |
| IS/IEC 60137: 2017 | - | Bushings for alternating voltages above 1000 Volts |
| IS 12676: 1989 (Reaffirmed Year: 2016) | - | Oil Impregnated Paper Insulated Condenser Bushings - Dimensions and Requirements |
| IS 4257: Part 1: 1981 (Reaffirmed Year: 2019) | - | Dimensions for Clamping Arrangements for Porcelain Transformer Bushings - Part I: For 12 kV to 36 kV Bushings |
| IS 4257: Part 2: 1986 (Reaffirmed Year: 2019) | - | Dimensions for clamping arrangements for porcelain transformer bushings: Part 2 For 72.5 kV and 123 kV bushings |
| IS 8603: 2008 (Reaffirmed Year: 2019) | - | Dimensions for porcelain transformers bushings for use in heavily polluted atmospheres 12/17.5kV, 24kV and 36kV |
| IS 8603: Part 4: 2003 (Reaffirmed Year: 2019) | - | Dimensions for Porcelain Transformer Bushings for Use in Heavily Polluted Atmospheres - Part 4 : 52 kV Bushings |
| ANSI-C57.12.80 | - | General requirements for Distribution, Power and Regulating Transformers |
| ANSI-C57.12.90 | - | Test Code for Distribution, Power and Regulation Transformers |
| NEMA-TR-1 | - | Transformers, Step Voltage Regulators and Reactors |
| IS 1747: 1972 (Reaffirmed Year: 2016) | - | Nitrogen |
| IS-5: 2007 | - | Colours for Ready Mixed Paints and Enamels |
| IS 3043: 2018 | - | Code of Practice for Earthing |
| IS 8263: 2018 | - | Radio Interference Test on High -Voltage Insulators (First Revision) |
| IS 8269: 1976 (Reaffirmed Year: 2014) | - | Methods for switching impulse tests on high voltage insulators |
| IS 2071: Part 1: 2016 | - | High-voltage Test Techniques Part 1 General Definitions and Test Requirements (Third Revision) |
| IS 16803: 2018 | - | High Voltage Test Techniques - Measurement of Partial Discharges by Electromagnetic and Acoustic Methods |
| IS/IEC 60270: 2000 (Reaffirmed Year: 2016) | - | High — Voltage Test Techniques — Partial Discharge Measurements |
| IS 13235: Part 1 : 2019 | - | Short-Circuit Currents — Calculation of Effects Part 1 Definitions and Calculation Methods (First Revision) |
| IS 13235: Part 2 : 2019 | - | Short-Circuit Currents — Calculation of Effects Part 2 Examples of Calculation (First Revision) |
| IS 16227: Part 1 : 2016 IEC 61869-2: 2007 | - | Instrument Transformers: Part 1 General requirements |

| | | |
|---|---|---|
| IS 16227: Part 2 : 2016 IEC 61869-2 : 2012 | - | Instrument Transformers Part 2 Additional Requirements for Current Transformers |
| IS 16227: Part 100: 2018 | - | Instrument Transformers Part 100 Guidance for Application of Current Transformers in Power System Protection |
| IS/IEC 60529: 2001 (Reaffirmed Year : 2019) | - | Degrees of protection provided by enclosures (IP CODE) |
| IS/IEC-60947 | - | Low voltage switchgear and control gear |
| IS 2062 : 2011 (Reaffirmed Year : 2016) | - | Hot Rolled Mediumand High Tensile Structural Steel |
| IS 9595 : 1996 (Reaffirmed Year : 2019) | - | Metal arc welding of carbon and carbon manganese steels - Recommendations |
| IS 10801 : 1984 (Reaffirmed Year : 2016) | - | Recommended procedure for heat treatment of welded fabrications |
| IS 4253 : Part 1 & 2 : 2008 (Reaffirmed Year : 2019) | - | Cork Composition Sheets |
| IS 11149 : 1984 (Reaffirmed Year : 2019) | - | Rubber Gaskets |
| IS 12444 : 1988 (Reaffirmed Year : 2015) | - | Continuously cast and rolled electrolytic copper wire rods for electrical conductors |
| IS 513 : 2016 | - | Cold Reduced Carbon Steel Sheet and Strip |
| IS 12615 : 2018 | - | Line Operated Three Phase A.C. Motors ( IE CODE ) "Efficiency Classes and Performance Specification" ( Third Revision ) |
| IS/IEC 60034 : PART 5 : 2000 (Reaffirmed Year : 2018) | - | Rotating electrical machines: Part 5 Degrees of protection provided by the integral design of rotating electrical machines (IP CODE) - Classification |
| IS 5561 : 2018 | - | Electric Power Connectors- Specification |
| IS 2932 : Part 1 : 2013 (Reaffirmed Year : 2018) | - | Enamel, Synthetic, Exterior: (a) Undercoating (b) Finishing - Specification: Part 1 for Domestic and Decorative Applications |
| IS 2074 : Part 1 : 2015 | - | Ready Mixed Paint, Air Drying, Red Oxide - Zinc Chrome, Priming - Specification |
| IS 3400 | - | Methods of Test for Vulcanized Rubber |
| IS 456 : 2000 (Reaffirmed Year : 2016) | - | Plain and Reinforced Concrete - Code of Practice (Including Amendment 1, 2, 3,& 4) |
| IS 13238 : 1991 (Reaffirmed Year : 2017) | - | Epoxy Based Zinc Phosphate Primer (two Pack) |
| IS 2848 : 1986 (Reaffirmed Year : 2016) | - | Industrial Platinum Resistance Thermometer Sensors |
| IS/IEC 61850 | - | Communication Networks and Systems for Power Utility Automation |
| IS 16683 : Part 1, 2 & 3 : 2018 | - | Selection and Dimensioning of High Voltage Insulators Intended for Use in Polluted Conditions |
| IEEE 1538-2000 | | Guide for determination of maximum winding temperature rise in liquid filled transformers |
| IEEE Standard C57.156- 2016 | | Guide for tank rupture mitigation of oil immersed transformers |
| IEEE Standard C57.150- 2012 | | Guide for Transformer Transportation |

| | | |
|---|---|---|
| IEEE Standard C57.149- 2012 | | Guide for the application and interpretation of Frequency Response Analysis of oil immersed transformers |
| IEEE Standard C57.104- 2019 | | Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers |
| IEC 60599-2015 | | Mineral oil-filled electrical equipment in service - Guidance on the interpretation of dissolved and free gases analysis |
| IEEE Std. C57.12.10 - 2017 | | Standard requirements for liquid immersed power transformers |
| IEEE Std. 57.104-2019 | | Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers |
| IEC 60599 | | Mineral oil-filled electrical equipment in service – Guidance on the interpretation of dissolved and free gases analysis |
| IEEE Std. 62-1995 | | Guide for Diagnostic Field Testing of Electric Power Apparatus - Part 1: Oil Filled Power Transformers, Regulators, and Reactors |
| CIGRE Technical Brochure No. 529 -2013 | | Guide lines for conducting design reviews for Power Transformers |
| CIGRE Technical Brochure No. 673-2016 | | Guide on Transformer Transportation |
| CIGRE Technical Brochure No. 530-2013 | | Guide for conducting factory capability assessment for Power Transformers |
| CIGRE Technical Brochure No. 761 (WG A2.49) | | Condition assessment of power transformers |
| CIGRE TB 209 | | Short Circuit Performance of Power Transformers |
| CIGRE TB 436 | | Experiences in service with new insulating liquids |
| Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations | | |
| Central Electricity Authority (Technical Standard for Construction of Electrical Plants and Electric Lines) Regulations | | |
| Central Electricity Authority (Installation and Operation of Meters)Regulations | | |
| CBIP Manual on Transformers (PublicationNo.317) | | |
| ISO 9001: Quality System – Model for Quality Assurance in Design/Development. | | |
| ISO-14001(Environmental Management System) | | |
| OHSAS18001(Occupational Health and Safety Management System) | | |

**Annexure-U**

## BASIC MANUFACTURING FACILITY & MANUFACTURING ENVIRONMENT

Customer/Purchaser always desires that transformer/reactor manufactured and delivered is of good quality and must perform trouble free service for its "Specified Design Life". The consistency in quality of material used & manufacturing process are main cause for variation in quality of transformer/reactor. It is also equally very important that transformer/reactor is manufactured in a clean dust free and humidity-controlled environment. Any compromise on this aspect will have adverse effect in expected design life of transformer/reactor, however good is the quality of material used. A broad list of facilities the transformer/reactor manufacturers should have are given below:

**Basic manufacturing facility**

Following manufacturing facility should be available for use with transformer and reactor manufacturer:

1. EOT Crane for main manufacturing bay and other shops (With Load Cell)
2. Vapor Phase Drying Oven (adequately sized to accommodate offered transformer and have facility to record temperature, vacuum, moisture etc.)
3. Air Casters for material handling
4. Core cutting line (if applicable)
5. Vacuum autoclaves
6. Air oven
7. Adjustable Horizontal and vertical winding machine
8. Winding Mandrels
9. Hydraulic Press
10. Brazing equipment
11. Mechanical platform
12. Tools and fixtures
13. Mechanical power press
14. Welding machines
15. Crimping tools
16. Faraday's cage
17. Motor Generator Set/Static Power System Set
18. Testing transformer
19. Capacitor bank
20. Impulse voltage generator
21. Capacitance & Tan delta bridge
22. Power Analyzer
23. Current & Voltage transformer
24. Partial Discharge (PD) measuring kit (for all manufacturers) & PD Diagnostic Kit (for 400KV & above voltage class Transformer/reactor manufacturer)
25. Temperature data logger
26. Noise measurement kit
27. Thermo vision camera
28. Loss measurement kit
29. Insulation tester
30. Winding resistance meter
31. Turn ratio meter
32. Transformer oil test lab
33. Dissolved Gas Analysis (DGA) test kit
34. Sweep Frequency Response Analyzer (SFRA) kit
35. Frequency Domain Spectroscopy (FDS) kit
36. NABL Accredited laboratory for testing
37. Oil Storage tanks

38. Oil filter plant with requisite level of vacuum and filter
39. Tensometer for Oil Surface tension
40. Particle Count Kit (for400kV&aboveTransformer/reactor)
41. Multimeters

**Manufacturing environment (Clean, dust free and humidity-controlled environment)**

A. Transformer must be manufactured in a bay having positive pressure w.r.t. external environment. Winding shall be manufactured in a clean, dust free and humidity-controlled environment. The dust particle shall be monitored regularly in the manufacturing areas. Further, there shall be positive atmospheric pressure, clean, dust free and humidity-controlled environment for following:

1. Insulation storage
2. Core storage
3. Glue stacking area
4. Core cutting line
5. Winding manufacturing bay
6. Core building area
7. Core coil assembly area
8. Testing lab
9. Packing & dispatch area

B. Following accessories to be kept in clean and covered location:

1. Piping
2. Radiator
3. Tank
4. Bushing (as per manufacturer's guideline)
5. Marshalling box
6. Turret
7. Conservator
8. Insulating oil

**Schedule-1**

**List of drawings to be submitted by successful bidder for approval of the**

**Project & Design Department**

| Sr. No. | Particulars of Drawing |
|---|---|
| 1 | General Arrangement (with provision of pockets for PT-100 sensors for remote /SCADA oil & Winding Temperature Indications) Overall dimensions to be restricted as per Clause 5.3 |
| 2 | List of fittings as per G.A. |
| 3 | Rating and diagram plate (additional information such as Guaranteed /Measured losses; Guaranteed /Measured impedances at extreme and normal taps; Guaranteed /Measured Temperature rises for oil & winding; Core weight; Copper weight and Core & winding weight shall be invariably mentioned) |
| 4 | Over loading plate |
| 5 | Valve Schedule Plate |
| 6 | Foundation Plan |
| 7 | Transport Outline |
| 8 | H.V. Bushing |
| 9 | I.V. Bushing (as per requirement) |
| 10 | L.V. Bushing |
| 11 | Neutral Bushing |
| 12 | Terminal connector for |
| | i) HV |
| | ii) I.V. (as per requirement) |
| | iii) LV. |
| | iv) Tertiary (as per requirement) |
| 13 | Neutral Grounding bar Assembly |
| 14 | L.V. grounding Assembly |
| 15 | Conservator Tank. |
| 16 | Magnetic Circuit Earthing Details |
| 17 | Equalizing Pipe arrangement. |
| 18 | Oil filling Instruction plate |
| 19 | OLTC shaft connection diagram. |
| 20 | OLTC equalizing Pipe arrangement |
| 21 | General Arrangement of RTCC |
| 22 | OLTC Schematic with group simultaneous mode of control. Connectivity for tap raise -lower operations and Tap Position Indication through SCADA & TMCTS |
| 23 | OLTC legend |
| 24 | Schematic wiring for RTCC panel |
| 25 | RTCC legend |
| 26 | Radiators. |
| 27 | General Arrangement of Cooling Control Cabinet |
| 28 | Cable termination plan (Co-ordination) between OLTC & RTCC |
| 29 | Schematic for Facia Annunciator |
| | Schematic wiring for cooler control comprising |
| | i) Cooler control legend |
| | ii) Main and standby supply circuit alongwith heater and lighting circuit |
| | iii) Power circuit for Fans Gr. I, Gr. II & Standby |

| | |
|---|---|
| | iv) Control circuit for Fans Gr. I, Gr. II & Standby |
| | v) Power circuit for pumps Gr. I, Gr. II and Standby (as per requirement) |
| | vi) Control circuit for Pumps Gr. I, Gr. II, (as per requirement) |
| | vii) Lamp indication circuit |
| | viii) Annunciation Circuit |
| | ix) Oil & Winding Temperature Local indicating circuit / Alarm & Trip circuit for oil temp and winding temperature. |
| | x) Alarm & Trip Circuit (for MOG, PRV, Main Buchholz & OLTC Buchholz |
| | xi)) Wiring diagram of PT - 100 (for remote / SCADA WDG Temp. and Oil Temp. Indication) |
| | xii) Cable Termination Plan (Co-ordination) between<br>a) FCC to RTCC |
| | b) FCC to OLTC |
| | c) FCC to C&R Panel |
| | xiii) Notes & Instructions |
| | xiv) REF Protection CT circuit. |
| 30 | Schematic wiring for TMCTS |
| 31 | General arrangement of optic fibre temperature measurement system. GA of Monitor Box and its schematic wiring diagram |
| 32 | General arrangement of on-line multi gas DGA for transformer oil and its schematic wiring diagram (as per requirement) |
| 33 | General arrangement of Condition controlled (Maintenance Free) Regenerating Silica Gel Breather for transformer oil (as per requirement) |
| 34 | Cable schedule |
| 35 | Roller Assembly |
| 36 | N2 Injection fire protection system drawing with Bill of material. (As per requirement) |
| 37 | HVWS fire protection system drawing with Bill of material. (As per requirement) |
| 38 | GTP for approval |
| 39 | Complete Bill of Materials. |
| 40 | QAP |
| 41 | Type Test Report conducted on identical transformer within last 5 years (if any) |
| 42 | $I^2R$ calculations |
| 43 | Impedance calculations |
| 44 | Short circuit calculations |
| 45 | Cooling calculations |
| 46 | Core cutting schedule (Core shall be cut at Mill's authorised processing unit only) |

**Schedule-2**
**Details of Loss Calculation**
**(to be filled in by the bidder and shall be submitted with technical bid)**

| Sl. No | Particulars | Values |
|---|---|---|
| 1. | Flux density at | |
| | (i) (145/36, 245/145, 245/145/36, 420/245) kV & 48.5 Hz, Tesla | |
| | (ii) (132/33, 220/132/33, 220/132, 132/33) kV & 50 Hz, Tesla. | |
| 2. | Core Data | |
| | (i) Core weight in Kg. | |
| | (ii) Gross core area [mm²] | |
| | (iii) Stacking factor. | |
| | (iv) Net core iron area [mm²] [ii x iii] | |
| 3. | Specific losses [W/Kg.] | |
| | (i) At maximum flux density corresponding to (145/36, 245/145, 245/145/36, 420/245) KV and 48.5 HZ. | |
| | (ii) At maximum flux density corresponding to (132/33, 220/132/33, 220/132, 132/33) KV and 50Hz. | |
| 4. | Volt ampere/Kg | |
| | (i) At maximum flux density corresponding to (145/36, 245/145, 245/145/36, 420/245) KV and 48.5 HZ. | |
| | (ii) At maximum flux density corresponding to (132/33, 220/132/33, 220/132, 132/33) KV and 50Hz. | |
| 5. | Calculated/guaranteed iron loss in KW at: | |
| | (i) Rated voltage and rated frequency | |
| | (ii) Rated voltage and rated frequency | |
| 6. | Current density [A/Sq. mm] for | |
| | (i) HV | |
| | (ii) LV | |
| 7. | Conductor size [in mm²] | |
| | (i) HV winding | |
| | a) Bare | |
| | b) Insulated | |
| | c) No of conductors in parallel | |
| | (ii) LV winding | |
| | a) Bare | |
| | b) Insulated | |
| | c) No of conductors in parallel | |
| 8. | Copper weight | |
| | (i) H.V. windings | |
| | (ii) LV windings | |
| | (iii) For Tap connections, | |
| | (iv) Total copper weight [i]+[ii]+[iii] | |
| 9. | L.V. winding resistance in ohms at 75°C/Phase. | |
| 10. | H.V. winding resistance in ohms at 75°C/Phase. | |
| | (i) At normal tap position | |
| | (ii) At maximum tap position | |
| | (iii) At minimum tap position | |
| 11. | Stray losses and eddy current losses [in KW] at 75°C | |
| | (i) At normal tap position | |

| Sl. No | Particulars | Values |
|---|---|---|
| | (ii) At maximum tap position | |
| | (iii) At minimum tap position | |
| 12. | Resistively of copper to be used for winding | |
| 13. | $I^2R$ loss at 75°C | |
| | (i) At normal tap position | |
| | (ii) At maximum tap position | |
| | (iii) At minimum tap position | |
| 14. | Calculated guaranteed copper losses [in KW] at 75°C [$I^2R$ ]loss + | |
| | (i) At normal tap position | |
| | (ii) At maximum tap position | |
| | (iii) At minimum tap position | |
| 15. | Guaranteed Auxiliary loss | |
| 16. | Computed/guaranteed total loss in KW at rated voltage and rated | |
| | (i) At normal tap position | |
| | (ii) At maximum tap position | |
| | (iii) At minimum tap position | |

NB: - 1. Approximate values in weight and losses etc. are not allowed.
2. Tolerance of + 5% in weights may be quoted without any approximation

Place:
Date:

Bidder's name:
Signature, designation, seal

**Schedule-3**
**Maximum Flux Density and Core Weight Calculation**
**(to be filled in by the bidder and shall be submitted with technical bid)**

| Step No | Width of steps [mm] | Stack Thickness [mm] | Gross Iron Area [mm²] |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |

Bmax = **E/ (4.44 x f x Ai x N)**

Where, E = L.V. winding phase voltage / phase
f = Rated frequency = 50 HZ.
Bmax. = Maximum flux density in Tesla.
Ai = Net iron area in sq.m = Gross iron area x stacking factor in sq.m
N = Number of L.V. winding, turns/phase
Stacking Factor = 0.97 maximum

**Core weight calculation**: -
Core dia [in mm] =
Window height [in mm] = Limb centre [in mm] =
Weight of core = [3 x window height + 4 x limb centre + 2 x max. width] x Net iron area x Density of core

NB: -
1 Specific loss vs. flux density graph for the type of core lamination to be used has to be furnished.
2. VA/Kg. Vs flux density graph for the core lamination to be used has to be furnished.
3. Any other factor assumed for above calculation to be explained with reasons.

**N.B: -The bidder may use its own method of calculation towards determination of maximum flux Density and weight of the core. But the same shall be supported with proper explanation and Justification.**

Place:
Date:

Signature of Bidder
With seal of Company

**Schedule-4**
**Manufacturer Quality Plan (MQP)**

| Sl No. | Component | Characteristics | Type of Inspection | Quantum of Inspection | Ref Doc & Acceptable Norm | Form of Record | Inspection Agency | Remarks |
|---|---|---|---|---|---|---|---|---|
| **1.0** | **MATERIAL** | | | | | | | |
| **1.1** | **Copper Conductor** | | | | | | | |
| 1.1.1 | | Sample check on winding conductor for electrical conductivity | Testing | Sampling/lot | TM Spec | Insp. record | Vendor/TM QC | CHP at Vendor end |
| 1.1.2 | | Dimensions Width & Thickness(Bare) & Visual for scratches, dentarks | Measurement | -Do- | TM Spec | -Do- | -Do- | CHP at Vendor end |
| 1.1.3 | | Sample check on insulating paper for pH value, electric strength | Testing | -Do- | TM Spec | -Do- | -Do- | TC Review |
| 1.1.4 | | check for bonding of the insulating paper with conductor | Visual | -Do- | TM Spec | -Do- | -Do- | CHP at Vendor end |
| 1.1.5 | | Check for the reaction of hot oil and insulating paper | Testing | -Do- | TM Spec | -Do- | -Do- | TC Review |
| 1.1.6 | | Check & ensure that physical condition of all materials taken for winding is satisfactory and dust free. | Visual | -Do- | TM Spec | -Do- | -Do- | CHP at Vendor end |
| **1.2** | **Core Material** | | | | | | | |
| 1.2.1 | | Sample testing of core materials for checking specific core loss properties, magnetization characteristics& Thickness | Testing | Sampling/lot | TM Spec | Insp. record | Vendor/TM QC | CHP at Vendor end |
| 1.2.2 | | Amount of burr | Measurement | -Do- | -Do- | -Do- | -Do- | CHP at Vendor end |
| **1.3** | **Insulating Material** | | | | | | | |
| 1.3.1 | | Physical Properties | Testing | Sampling /l ot | TM Spec | Insp. record | Vendor/TM QC | TC Review |
| 1.3.2 | | Dielectric Strength | Testing | Sampling/lot | TM Spec | Insp.record | Vendor/TM | TC |

| Sl No. | Component | Characteristics | Type of Inspection | Quantum of Inspection | Ref Doc & Acceptable Norm | Form of Record | Inspection Agency | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | QC | Review |
| 1.3.3 | | Reaction of hot oil on insulating materials | Testing | Sampling/ lot | TM Spec | Insp. record | Vendor/TM QC | TC Review |
| **1.4** | **OIL** | | | | | | | |
| 1.4.1 | | Appearance | Visual | Sampling | IS 335/TM Spec | Insp Record | Vendor/TM QC | CHP at Vendor end |
| 1.4.2 | | Density | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.3 | | Viscosity | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.4 | | Interfacial tension | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.5 | | Neutralisation Value | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.6 | | Dielectric strength | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.7 | | Tan Delta | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.8 | | Specific Resistance | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.9 | | Water content | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.10 | | Flash point | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.11 | | Pour point | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.12 | | Corrosive sulphur | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.13 | | Oxidation stability (a) Neutralization after oxidation (b)Total sludge after Oxidation | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.14 | | Ageing characteristics after accelerated ageing | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.15 | | Presence of oxidation Inhibitor | Testing | -Do- | -Do- | -Do- | -Do- | |
| 1.4.16 | | SK value | Testing | -Do- | -Do- | -Do- | -Do- | |
| **2.0** | **FITTINGS AND ACCESSORIES** | | | | | | | |
| **2.1** | Tank & Conservator Raw material | | | | | | | |
| 2.1.1 | | Type of material | TC Verif | Sampling | TM Spec | Insp Record | Vendor/TM QC | |
| 2.1.2 | | Thickness | Testing | -Do- | -Do- | -Do- | -Do- | CHP at Vendor end |
| **2.2** | **Tank & conservator Assembly** | | | | | | | |
| 2.2.1 | | Inspection of major welds. | Visual | Each Unit | TM Spec | Insp Record | Vendor/TM QC | CHP at Vendor end |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2.2.2 | | NDT for load bearing(Jacking pad, lifting bollard) | Testing | Each Unit | TM Spec | Insp Record | Vendor/TM QC | CHP at Vendor end |
| Sl No. | Component | Characteristics | Type of Inspection | Quantum of Inspection | Ref Doc & Acceptable Norm | Form of Record | Inspection Agency | Remarks |
| | | Welds(DP test) | | | | | | |
| 2.2.3 | | dimensions between wheels, demonstrate turning of wheels through 90 deg. & further dimensional check | Testing | Each Unit | TM Spec | Insp Record | Vendor/TM QC | CHP at Vendor end |
| 2.2.4 | | Leakage Test of conservator | Testing | Each Unit | TM Spec | Insp Record | Vendor/TM QC | CHP at Vendor end |
| 2.2.5 | | Measurement of film thickness of | Testing | Each Unit | TM Spec | Insp Record | Vendor/TM QC | CHP at TM for total DFT measure ment during final inspection n |
| | | (i) Zinc chromate paint | Meas | -Do- | -Do- | -Do- | -Do- | |
| | | (ii) Finished coat | Meas | -Do- | -Do- | -Do- | -Do- | |
| 2.2.6 | | -Pressure &Vacuum test | One unit/ Rating | -Do- | -Do- | -Do- | -Do- | CHP at Vendor end |
| **2.3** | **Radiator** | | | | | | | |
| 2.3.1 | | Visual & Dimension | Measurem ent | Each Unit | TM Spec | Insp Record | Vendor/TM QC | |
| 2.3.2 | | Pressure test & leakage test | Testing | -Do- | -Do- | -Do- | -Do- | |
| 2.3.3 | | Paint thickness | Measurem ent | -Do- | -Do- | -Do- | -Do- | |
| **2.4** | **Marshalling box & RTCC** | | | | | | | |
| 2.4.1 | | Dimension (WxDxHof panel) | Measure ment | Each Unit | TM Spec | Insp Record | Vendor/TM QC | |
| 2.4.2 | | Meas. of 2 kV dielectric test | Testing | -Do- | -Do- | -Do- | -Do- | CHP |
| 2.4.3 | | Component make & Rating | Visual | -Do- | -Do- | -Do- | -Do- | |
| 2.4.4 | | Completeness, label Fixing & finishing | Visual | -Do- | -Do- | -Do- | -Do- | |
| 2.4.5 | | Functional test | Visual | -Do- | -Do- | -Do- | -Do- | |
| 2.4.6 | | IP:55 test for M. Box | Testing | 1 unit/rating | IS 2147 | -Do- | -Do- | CHP |
| **2.5** | **Temperature indicators (OTI, WTI)** | | | | | | | |
| 2.5.1 | | Type | Visual | Each Unit | TM Spec | Insp Record | Vendor/TM 's QC | |
| 2.5.2 | | Continuity check | Manual | -Do- | -Do- | -Do- | -Do- | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2.5.3 | | Switch setting & calibration | -Do- | -Do- | -Do- | -Do- | -Do- | |
| **2.6** | **Buchholz Relay** | | | | | | | |
| 2.6.1 | | Type/Model | Visual | -Do- | -Do- | -Do- | -Do- | |
| 2.6.2 | | Continuity of Contacts | Manual Check | -Do- | -Do- | -Do- | -Do- | |
| 2.6.3 | | Operation of contacts | Manual Check | -Do- | -Do- | -Do- | -Do- | |
| **2.7** | **Bushings** | | | | | | | |
| 2.7.1 | | Test for leakage on | TC Verify | Each Unit | IS 2099/TM | Insp | Vendor/TM | |

| Sl No. | Component | Characteristics | Type of Inspection | Quantum of Inspection | Ref Doc & Acceptable Norm | Form of Record | Inspection Agency | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | internal fillings (Tightness test) | | | Spec | Record | 's QC | |
| 2.7.2 | | Dry power frequency test on terminal & tapping | TC Verif | Each Unit | IS 2099/TM Spec | Insp Record | Vendor/TM 's QC | |
| 2.7.3 | | Measurement of dielectric dissipation factor& capacitance | TC Verif | Each Unit | IS 2099/TM Spec | Insp Record | Vendor/TM 's QC | |
| 2.7.4 | | Partial discharge test followed by dielectric dissipation factor &capacitance measurement for condenser bushings & creepage distance measurement | Testing | Each Unit | IS 2099/TM Spec | Insp Record | Vendor/TM 's QC | CHP at Vendor end |
| **2.8** | **Current Transformers** | | | | | | | |
| 2.8.1 | | Type & finish | Visual | Each lot | TM's Spec | Insp Record | Vendor/TM 's QC | |
| 2.8.2 | | Dimensions (OD,ID & H) | Measur | Each Unit | -Do- | -Do- | -Do- | |
| 2.8.3 | | Verification of Terminal Marking& Polarity | Testing | Each Unit | -Do- | -Do- | -Do- | |
| 2.8.4 | | P.F.dry withstand test | -Do- | -Do- | -Do- | -Do- | -Do- | |
| 2.8.5 | | Overvoltage Inter turn test | -Do- | -Do- | -Do- | -Do- | -Do- | |
| 2.8.6 | | Determination of errors | -Do- | -Do- | -Do- | -Do- | -Do- | |
| **2.9** | **Pressure relief Valve/Sudden pressure relay** | | | | | | | |
| 2.9.1 | | Type/ Model | Visual | Each Unit | TMs Spec | Insp Record | Vendor/TM 's QC | |
| 2.9.2 | | Manual operation of Switch contacts | Manual Check | -Do- | -Do- | -Do- | -Do- | |
| 2.9.3 | | Operating pressure | Testing | -Do- | -Do- | -Do- | -Do- | |
| **2.10** | **MOLG** | | | | | | | |
| 2.10.1 | | Type/ Model | Visual | Each Unit | TMs Spec | Insp Record | Vendor/TM 's QC | |
| 2.10.2 | | Dial Calibration | TC Verif | -Do- | -Do- | -Do- | -Do- | |
| 2.10.3 | | Switch Continuity | Manual Check | -Do- | -Do- | -Do- | -Do- | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2.11** | **Valves** | | | | | | | |
| 2.11.1 | | Type & Size | Visual | Each Unit | Customer Spec | Insp Record | Vendor/TM 's QC | |
| 2.11.2 | | Open & shut marking | -Do- | -Do- | -Do- | -Do- | -Do- | |
| 2.11.3 | | Leakage test | TC Varif | | | | | |
| **2.12** | **Silica gel breather** | | | | | | | |
| 2.12.1 | | Type/ Model | Visual | Each Unit | TMs Spec | Insp Record | Vendor/TM 's QC | |
| **2.13** | **Online $H_2$& Moisture monitoring** | | | | | | | |
| 2.13.1 | | Type / Model | Visual | Each Unit | TMs Spec | Insp | Vendor/TM | |

| Sl No. | Component | Characteristics | Type of Inspection | Quantum of Inspection | Ref Doc & Acceptable Norm | Form of Record | Inspection Agency | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Record | 's QC | |
| **2.14** | **Tap changer** | | | | | | | |
| 2.14.1 | | Type & Rating | Visual | Each Unit | TMs Spec | Insp Record | Vendor/TM 's QC | |
| 2.14.2 | | Physical condition | Visual | Each Unit | TMs Spec | Insp Record | Vendor/TM 's QC | |
| 2.14.3 | | Mechanical Operation Check | Testing | Each Unit | TMs Spec | Insp Record | Vendor/TM 's QC | |
| 2.14.4 | | Insulation Resistance Test | Testing | Each Unit | TMs Spec | Insp Record | Vendor/TM 's QC | |
| **2.15** | **Cooling fan** | | | | | | | |
| 2.15.1 | | HV test | Testing | Each Unit | IS 2312 | Insp Record | Vendor/TM 's QC | |
| 2.15.2 | | Insulation Resistance Test | -Do- | -Do- | -Do- | -Do- | -Do- | |
| 2.15.3 | | Performance Test | -Do- | -Do- | -Do- | -Do- | -Do- | |
| 2.15.4 | | DFT of Galvanization on Fan guard | -Do- | -Do- | TM's Spec | -Do- | -Do- | |
| **3.0** | **MANUFACTURING** | | | | | | | |
| **3.1** | **Assembled Core** | | | | | | | |
| 3.1.1 | | Visual & dimensional check during assembly stage | Visual/ Meas | Each Assembly | TM's Spec | Insp Record | Vendor/TM 's QC | CHP at TM's Works |
| 3.1.2 | | Check on completed core for measurement of iron loss | Meas/ Testing | Each Assembly | Customer Spec | Insp Record | Vendor/TM 's QC | CHP at TM's Works |
| 3.1.3 | | 2KV H.V.test (Core insulation test) between Core &clamps for one minute And Insulation resistance test of core & clamps (clamps) | Testing | Each Assembly | Customer Spec | Insp Record | Vendor/TM 's QC | CHP at TM's Works |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3.1.4 | | Visual & dimensional checks for straightness &roundness of core, thickness of limbs and suitability of clamps | Visual | -Do- | -Do- | -Do- | -Do- | CHP at TM's Works |
| **3.2** | **Wound Coils** | | | | | | | |
| 3.2.1 | | Visual check for brazed joints wherever applicable | Visual | Sampling/L ot | TM's Spec | Insp Record | Vendor/TM 's QC | CHP at TM's Works |
| 3.2.2 | | Visual check of insulation on the conductors & between the windings | Visual | Sampling/L ot | TM's Spec | Insp Record | Vendor/TM 's QC | CHP at TM's Works |
| 3.2.3 | | Check for the | Testing | -Do- | -Do- | -Do- | -Do- | CHP at |

| Sl No. | Component | Characteristics | Type of Inspection | Quantum of Inspection | Ref Doc & Acceptable Norm | Form of Record | Inspection Agency | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | absence of short circuit between parallel strands of PICC | | | | | | TM's Works |
| **3.3** | **Coil & Core assembled** | | | | | | | |
| 3.3.1 | | Active part before drying | | | | | | |
| | | (i) Visual check | Visual | Each Unit | TM's Spec | Insp Record | Vendor/TM 's QC | CHP at TM's Works |
| | | (ii) Check insulation distance between high voltage connections, between high voltage connection cables & earth and other live parts | Meas | -Do- | -Do- | -Do- | -Do- | CHP at TM's Works |
| | | (iii) Check insulating distance between low voltage connections and earth and other parts | Meas | -Do- | -Do- | -Do- | -Do- | CHP at TM's Works |
| | | (iv) 2KV core insulation test | Testing | -Do- | -Do- | -Do- | -Do- | CHP at TM's Works |
| 3.3.2 | Active part after drying | | | | | | | |
| | | (i) Measurement& recording of temperature & drying time during vacuum treatment | VPD Data | Each Unit | TM's Spec | Insp Record | TM's testing/TM' sQC | **In process check card review by Custome r** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | (ii) Check for completeness of drying | VPD Data | Each Unit | TM's Spec | Insp Record | TM's testing/TM' sQC | **In process check card review by Customer** |
| **3.4** | **Assembled Transformer** | | | | | | | |
| 3.4.1 | | Check Completed transformer against approved outline drawing, provision for all fittings, finish levels etc. | Visual | One Transform er of each rating | Approved GA drawing | Insp Record | TM's testing/TM' sQC | **CHP at TM's Works** |
| 3.4.2 | | Jacking test | Visual | -Do- | -Do- | -Do- | -Do- | **CHP at TM's Works** |
| **3.5** | **Final Testing** | | | | | | | |
| 3.5.1 | **Routine Tests** | | | | | | | |

| Sl No. | Component | Characteristics | Type of Inspection | Quantum of Inspection | Ref Doc & Acceptable Norm | Form of Record | Inspection Agency | Remarks |
|---|---|---|---|---|---|---|---|---|
| 3.5.1.1 | | Winding resistance test | Testing | Each Unit | IS 2026/IEC 60076 | Insp Record | Customer/ TM | **CHP at TM's Works** |
| 3.5.1.2 | | Turn ratio, Polarity | | | | | | |
| 3.5.1.3 | | Vector group test and Phase vector relationship test | | | | | | |
| 3.5.1.4 | | Load loss & impedance voltage | | | | | | |
| 3.5.1.5 | | No-load loss and current measurement | | | | | | |
| 3.5.1.6 | | Measurement of magnetization current at low voltage | | | | | | |
| 3.5.1.7 | | Insulation Resistance measurement | | | | | | **CHP at TM's Works** |
| 3.5.1.8 | | Separate source voltage withstand test for all windings (1 Minute) | | | | | | |
| 3.5.1.9 | | Induced over- voltage withstand test for 60 Sec. @ 100 Hz | | | | | | |
| 3.5.1.10 | | Full wave lightning impulse on three phases | | | | | | |
| 3.5.1.11 | | Measurement of partial discharge at the time of induced over voltage test | | | | | | |
| 3.5.1.12 | | Frequency response analysis (FRA) | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3.5.1.13 | | Measurement of zero sequence impedance of three phase transformers | | | | | | |
| 3.5.1.14 | | Measurement of Acoustic noise level | | | | | | |
| 3.5.1.15 | | Measurement of the harmonics of the no-load current | | | | | | |
| 3.5.1.16 | | Measurement of capacitance and ten δ to determine capacitance between winding and earth. Value of tanδ should not be more than 0.5% at 20°C | | | | | | |
| 3.5.1.17 | | Oil leakage test on | | | | | | |
| Sl No. | Component | Characteristics | Type of Inspection | Quantum of Inspection | Ref Doc & Acceptable Norm | Form of Record | Inspection Agency | Remarks |
| | | transformer tank as per CBIP | | | | | | |
| 3.5.1.18 | | Test on OLTC | | | | | | |
| 3.5.1.19 | | Magnetic balance test | | | | | | |
| 3.5.2 | **Type Test** | | | | | | | |
| 3.5.2.1 | | Temperature-rise test with 2 x 50% radiator banks including DGA test after & before temp rise test | Testing | One Unit on each rating | IS 2026/IEC 60076 | Insp Record | Customer/ TM | **CHP at TM's Works** |
| 3.5.2.2 | | Measurement of the power taken by the fans | | | | | | **CHP at TM's Works** |
| 3.5.2.3 | | Pressure &Vacuum test on transformer tank as per CBIP | | | | | | |
| **3.6** | **Pre-shipment check** | | | | | | | |
| 3.6.1 | | Detach accessories for despatch | Visual | Each unit | TM's spec | Insp Record | TM | |
| 3.6.2 | | Blanking of openings | -Do- | -Do- | -Do- | -Do- | -Do- | |
| 3.6.3 | | Adjustment of oil Level/ Draining of oil | -Do- | -Do- | -Do- | -Do- | -Do- | |
| 3.6.4 | | Finishing, cleaning &Painting touch up | -Do- | -Do- | -Do- | -Do- | -Do- | |
| 3.6.5 | | Dew point measurement before despatch | Testing | -Do- | -Do- | -Do- | -Do- | **Reqd for only Transformer despatch without oil** |
| 3.6.6 | | Gas tightness test to confirm tightness | Testing | -Do- | -Do- | -Do- | -Do- | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3.6.7 | | Check for proper packing of detached accessories for dispatch & Check for proper provision of bracing to arrest the movement of core & winding assembly inside the tank | Testing | -Do- | -Do- | -Do- | -Do- | |

Note:

1. TM – Transformer Manufacturer
2. CHP – Customer Hold Point

## Schedule – 5
## Guaranteed and Other Technical Particulars
## (to be filled in by the bidder and shall be submitted with technical bid)

| S. No | Description | Particulars |
|---|---|---|
| **1.0** | Manufacturer's Name & Address of manufacturing plant | |
| **2.0** | Standard applicable | |
| **3.0** | Rating (MVA) | |
| **4.0** | Voltage ratio (kV) | |
| **5.0** | Winding connection | |
| **6.0** | Vector group | |
| **7.0** | Number of phases | |
| **8.0** | Frequency (Hz) | |
| **9.0** | Type of cooling | |
| **10.0** | **Rating available at any tapping with ONAN cooling** | |
| | (i). HV (MVA) | |
| | (ii). IV (MVA) | |
| | (iii). LV (MVA) | |
| **11.0** | **Rating available at any tapping with ONAF cooling** | |
| | (i). HV (MVA) | |
| | (ii). IV (MVA) | |
| | (iii). LV (MVA) | |
| **12.0** | **Rating available at any tapping with OFAF cooling** | |
| | (i). HV (MVA) | |
| | (ii). IV (MVA) | |
| | (iii). LV (MVA) | |
| **13.0** | **Permissible overload** | |
| **14.0** | **Impedance Data** | |
| 14.1 | Ohmic impedance at $75^0$ C and rated frequency based on rated power on HV winding (%) | |
| | (i). HV/IV | |
| | ➢ Principal tap | |
| | ➢ Maximum tap | |
| | ➢ Minimum tap | |
| | (ii). HV/LV | |
| | ➢ Principal tap | |
| | ➢ Maximum tap | |

| S. No | Description | Particulars |
|---|---|---|
| | ➢ Minimum tap | |
| | (iii). IV/LV | |
| | ➢ Principal tap | |
| | ➢ Maximum tap | |
| | ➢ Minimum tap | |
| 14.2 | Tolerance applicable to above impedance | |
| | (i). HV/IV | |
| | ➢ Principal tap | |
| | ➢ Maximum tap | |
| | ➢ Minimum tap | |
| | (ii). HV/LV | |
| | ➢ Principal tap | |
| | ➢ Maximum tap | |
| | ➢ Minimum tap | |
| | (iii). IV/LV | |
| | ➢ Principal tap | |
| | ➢ Maximum tap | |
| | ➢ Minimum tap | |
| 14.3 | Zero sequence impedance (%) | |
| | (i). HV/IV | |
| | ➢ Principal tap | |
| | ➢ Maximum tap | |
| | ➢ Minimum tap | |
| | (ii). HV/Neutral | |
| | ➢ Principal tap | |
| | ➢ Maximum tap | |
| | ➢ Minimum tap | |
| | (iii). IV/ Neutral | |
| | ➢ Principal tap | |
| | ➢ Maximum tap | |
| | ➢ Minimum tap | |
| 14.4 | Minimum Air core impedance (%) | |
| **15.0** | **Guaranteed Losses& Tolerances** | |
| 15.1 | **Guaranteed Losses** | |

| S. No | Description | Particulars |
|---|---|---|
| | a) No load loss on principal tap at rated voltage and frequency (KW) | |
| | b) Load loss (Copper Loss) at rated HV and IV load without LV loading at principal tap at 75ºC (KW) | |
| | c) Cooler loss (KW) | |
| | d) Total loss (a+b+c) (KW) | |
| 15.2 | **Tolerances if applicable on above losses** | |
| | a) No load loss on principal tap at rated voltage and frequency (KW) | |
| | b) Load loss (Copper Loss) at rated HV and IV load without LV loading at principal tap at 75ºC (KW) | |
| | c) Cooler loss (K/W) | |
| | d) Total loss (a+b+c), (KW) | |
| **16.0** | **Cooling Equipment Details** | |
| 16.1 | Number of radiator bank and its rating as % of transformer cooling | |
| 16.2 | Radiator | |
| | a) Type of mounting | |
| | b) Material | |
| | c) Thickness | |
| 16.3 | Number of fans per radiator bank | |
| 16.4 | Temperature range for which setting is adjustable | |
| **17.0** | **Thermal Data** | |
| 17.1 | Temperature rise in top oil over an ambient of $50^0$ C. ($^0$C) | |
| 17.2 | Temperature rise in winding by resistance measurement method over an ambient of $50^0$ C. ($^0$C) | |
| 17.3 | Winding hotspot temperature over an ambient of$50^0$ C. ($^0$C) | |
| 17.4 | Core hotspot temperature over an ambient of $50^0$ C. ($^0$C) | |
| 17.5 | Position of core hotspot | |
| 17.6 | Thermal time constant (Hours) | |
| **18.0** | **Maximum noise level at** | |
| 18.1 | ONAN cooling (dBA) | |
| 18.2 | Full load with 100% cooling (dBA) | |
| **19.0** | **Maximum partial discharge level at 1.5 pu (pC)** | |
| **20.0** | **Core** | |
| 20.1 | Manufacturer of core material | |
| 20.2 | Type of construction (core/shell) | |
| 20.3 | Diameter of the core (mm) | |

| S. No | Description | Particulars |
|---|---|---|
| 20.4 | Core area ($mm^2$) | |
| | a) Yoke | |
| | b) Wound limb | |
| | c) Unwound limb | |
| 20.5 | Core material and grade used | |
| 20.6 | Type of joint between core and yoke | |
| 20.7 | Thickness of stamping (mm) | |
| 20.8 | Percentage silicon content (%) | |
| 20.9 | Maximum flux density in core at rated frequency and at | |
| | a) 90% voltage (wb/sq.m) | |
| | b) 100% voltage (wb/sq.m) | |
| | c) 110% voltage (wb/sq.m) | |
| **21.0** | **Over excitation withstand time (secs.)**. | |
| 21.1 | 1.05 Um | |
| 21.2 | 1.25 Um | |
| 21.3 | 1.50 Um | |
| **22.0** | **Winding** | |
| 22.1 | Type of winding | |
| | a) HV | |
| | b) IV | |
| | c) LV | |
| | d) Regulating | |
| 22.2 | Current density at rated load | |
| | a) HV | |
| | b) IV | |
| | c) LV | |
| 22.3 | Conductor area | |
| 22.4 | a) HV | |
| 22.5 | b) IV | |
| 22.6 | c) LV | |
| 22.7 | Maximum current density under short circuit | |
| 22.8 | a) HV | |
| 22.9 | b) IV | |
| 22.10 | c) LV | |
| 22.11 | Magnetizing inrush current (Amps) | |
| 22.12 | No load current (Amps) at rated frequency and at | |
| | a) 90% voltage | |
| | b) 100% voltage | |
| | c) 110% voltage | |

| S. No | Description | Particulars | | |
|---|---|---|---|---|
| 22.13 | Voltage per turn for maximum flux density | | | |
| | a) HV (Volts) | | | |
| | b) IV (Volts) | | | |
| | c) LV (Volts) | | | |
| 22.14 | Resistance | | | |
| | a) HV (Ohms) | | | |
| | b) IV (Ohms) | | | |
| | c) LV (Ohms) | | | |
| 22.15 | Number of turns in | | | |
| | a) HV | | | |
| | b) IV | | | |
| | c) LV | | | |
| | d) Regulating | | | |
| 22.16 | Position of winding from the core(Enclose a sketch) | | | |
| | a) HV | | | |
| | b) IV | | | |
| | c) LV | | | |
| | d) Regulating | | | |
| 22.17 | Type of Conductor | | | |
| | a) HV | | | |
| | b) IV | | | |
| | c) LV | | | |
| | d) Regulating | | | |
| 22.18 | Maximum average radial compressive stress in the winding | | | |
| | a) For CTC/epoxy bonded conductor (N/sq.mm) | | | |
| | b) For paper insulated conductor (N/sq.mm) | | | |
| 22.19 | Insulation system | | | |
| | Min$^{m}$ density of press board (gm/cc) | | | |
| | Min$^{m}$ Density of paper ( gm/cc) | | | |
| **23.0** | **Insulation Level of Winding** | HV | IV | LV |
| 23.1 | Lightning impulse withstand voltage (kVp) | | | |
| 23.2 | Switching Surge withstand voltage (kVp) | | | - |

| S. No | Description | Particulars | | | |
|---|---|---|---|---|---|
| 23.3 | Power Frequency withstand voltage (kV rms) | - | | | |
| 23.4 | Maximum transferred surge voltage due to rated LI/SI voltage on HV & IV. (kV peak) | - | - | | |
| **24.0** | **Short circuit withstand current & duration** | | | | |
| 24.1 | Short circuit current for which transformer is designed to withstand in p.u of rated rms current | | | | |
| | (i). HV | | | | |
| | (ii). IV | | | | |
| | (iii). LV | | | | |
| 24.2 | Withstand time for three phase short circuit at terminals (secs.) | | | | |
| **25.0** | **Capacitance Values** | | | | |
| 25.1 | HV to earth(pF) | | | | |
| 25.2 | IV to earth(pF) | | | | |
| 25.3 | LV to earth(pF) | | | | |
| **26.0** | **Tank** | | | | |
| 26.1 | Type of Tank cover (Conventional / Bell) | | | | |
| 26.2 | Material | | | | |
| 26.3 | Approximate thickness of | | | | |
| | (i). Sides (mm) | | | | |
| | (ii). Bottom (mm) | | | | |
| | (iii). Cover (mm) | | | | |
| 26.4 | Type of Tank cover joint | | | | |
| **27.0** | **Vacuum withstand capability of** | | | | |
| 27.1 | Main tank (torr) | | | | |
| 27.2 | Radiators and accessories (torr) | | | | |
| **28.0** | **Pressure withstanding capability of** | | | | |
| 28.1 | Main tank (torr) | | | | |
| 28.2 | Radiators and accessories (torr) | | | | |
| **29.0** | **Gasket** | | | | |
| 29.1 | Material | | | | |
| 29.2 | Temperature withstand capability (°C) | | | | |
| **30.0** | **Size of oil filter hose (mm)** | | | | |
| **31.0** | **Bushings** | HV | IV | LV | Neutral |
| 31.1 | Name of Manufacturer | | | | |
| 31.2 | Rated Voltage (kV) | | | | |

| S. No | Description | Particulars | | | |
|---|---|---|---|---|---|
| 31.3 | Rated current (Amps) | | | | |
| 31.4 | Total creepage distance (mm) | | | | |
| 31.5 | Protected creepage distance (mm) | | | | |
| 31.6 | Insulation Level | | | | |
| | a) Lightning impulse withstand voltage (kVp) | | | | |
| | b) Switching Surge withstand voltage (kVp) | | | | |
| | c) Power Frequency withstand voltage (kV rms ) | | | | |
| 31.7 | Colour of porcelain | | | | |
| 31.8 | Mounting | | | | |
| **32.0** | **Bushing Current Transformer on Auto Transformer** | | | | |
| 32.1 | **HV Side** | | | | |
| | (i). Type or voltage class | | | | |
| | (ii). Ratio | | | | |
| | (iii). Accuracy class | | | | |
| | (iv). Burden (VA) | | | | |
| | (v). Accuracy limit factor | | | | |
| | (vi). Knee point voltage (Volts) (minimum) | | | | |
| | (vii). Maximum resistance of secondary winding | | | | |
| | (viii). Maximum exciting (mA) current | | | | |
| 32.2 | **IV Side** | | | | |
| | (i). Type or voltage class | | | | |
| | (ii). Ratio | | | | |
| | (iii). Accuracy class | | | | |
| | (iv). Burden (VA) | | | | |
| | (v). Accuracy limit factor | | | | |
| | (vi). Knee point voltage (Volts) (minimum) | | | | |
| | (vii). Maximum resistance of secondary winding | | | | |
| | (viii). Maximum exciting (mA) current | | | | |
| 32.3 | **Neutral Side** | | | | |
| | (i). Type or voltage class | | | | |
| | (ii). Ratio | | | | |
| | (iii). Accuracy class | | | | |
| | (iv). Burden (VA) | | | | |
| | (v). Accuracy limit factor | | | | |

| S. No | Description | Particulars |
|---|---|---|
| | (vi). Knee point voltage (Volts) (minimum) | |
| | (vii). Maximum resistance of secondary winding | |
| | (viii). Maximum exciting (mA) current | |
| **33.0** | **Clearances** | |
| 33.1 | Minimum clearance between phases and phase to earth | |
| | (i). In oil (mm) | |
| | (ii). In air (mm) | |
| 33.2 | Minimum clearance of HV winding to tank in oil (mm) | |
| 33.3 | Minimum clearance of HV winding to earth in oil (mm) | |
| 33.4 | Clearance between Core and Coil (mm) | |
| 33.5 | Clearance between coils (mm) | |
| 33.6 | Clearance between neutral to ground in air (mm) | |
| **34.0** | **Tap changing Equipment rating** | |
| 34.1 | Manufacturer & type designation | |
| 34.2 | Voltage class & current | |
| 34.3 | Number of steps | |
| 34.4 | Range | |
| 34.5 | Step voltage | |
| 34.6 | Electrical location of tapping (HV/IV/Neutral) | |
| 34.7 | Rated voltage of drive motor (volts) | |
| 34.8 | No. of revolutions to complete one step | |
| 34.9 | Time to complete one step on manual/auto operation (secs.) | |
| 34.10 | Power required (kW) | |
| 34.11 | Insulation level of tap changer | |
| 34.12 | Short circuit withstand current | |
| 34.13 | Value of tie-in-resistor and connection m) arrangement (if provided) | |
| 34.14 | No load voltage appearing on | |
| | (i). Principal tap | |
| | (ii). Maximum tap | |
| | (iii). Minimum tap | |
| **35.0** | **Conservator** | |
| 35.1 | Total volume (Litres) | |
| 35.2 | Volume between highest and lowest levels | |
| **36.0** | **Air Cell (oil preservation)** | |

| S. No | Description | Particulars | |
|---|---|---|---|
| 36.1 | Material of air cell | | |
| 36.2 | Continuous temp. withstand capability of the air cell | | |
| **37.0** | **Pressure Relief Device** | | |
| 37.1 | Manufacturer & type designation | | |
| 37.2 | No. of pressure relief device provided | | |
| 37.3 | Operating pressure of pressure relief device | | |
| **38.0** | **Insulating Oil** | | |
| 38.1 | Manufacturer of the Oil | | |
| 38.2 | Standards applicable | | |
| 38.3 | Type of oil (Non inhibited / inhibited) | | |
| 38.4 | Moisture Content (ppm) | Before first filling | Before commissioning |
| 38.5 | Max. tan-delta value (at 90 deg. C.) | | |
| 38.6 | Resistivity (ohm-cm) | | |
| 38.7 | Breakdown Strength (kV) | | |
| 38.8 | Interfacial tension at 20°C (min.) | | |
| **39.0** | **Temperature Indicators** | | |
| 39.1 | Oil Temperature Indicator | | |
| | (i). Name of Manufacturer | | |
| | (ii). Range | | |
| | (iii). Accuracy | | |
| 39.2 | Winding Temperature Indicator | | |
| | (i). Name of Manufacturer | | |
| | (ii). Range | | |
| | (iii). Accuracy | | |
| 39.3 | RWTI | | |
| | (i). Name of Manufacturer | | |
| | (ii). Range | | |
| | (iii). Accuracy | | |
| | (iv). Auxiliary supply used | | |
| **40.0** | **On line oil drying system** | | |
| 40.1 | Name of Manufacturer & type designation | | |
| 40.2 | Number & Capacity of drying element for each transformer | | |
| 40.3 | Moisture absorption capacity | | |

| S. No | Description | Particulars |
|---|---|---|
| **41.0** | **On line dissolved hydrogen gas & moisture monitoring system** | |
| 41.1 | Name of Manufacturer & type designation | |
| 41.2 | Name of gases monitored | |
| 41.3 | Nos. of Potential free contacts for monitoring, Alarm, equipment healthiness etc | |
| **42.0** | **Buchholz Relay** | |
| 42.1 | Name of Manufacturer & type designation | |
| **43.0** | **Furnish details of processing of core coil assembly including drying method, temperature, vacuum level, clamping pressure etc.** | |
| **44.0** | **Approximate dimensions** | |
| 44.1 | Tank (L x B x H) (mm) | |
| 44.2 | Overall dimensions with coolers (L x B x H) (mm) | |
| 44.3 | Shipping dimensions (L x B x H) (mm) | |
| 44.4 | Height for un-tanking (mm) | |
| 44.5 | Dimensions of largest package (L x B x H) (mm) | |
| **45.0** | **Weights of Transformer Components** | |
| 45.1 | Core (kg) | |
| 45.2 | Windings (Kg) | |
| 45.3 | Core & winding assembly (kg) | |
| 45.4 | Insulation (Kg) | |
| 45.5 | Tank and fittings (Kg) | |
| 45.6 | Oil (Kg) | |
| 45.7 | Untanking weight (heaviest piece) (Kg) | |
| 45.8 | Total weight (Kg) | |
| 45.9 | Weight of heaviest package (Kg) | |
| 45.10 | Total shipping weight (Kg ) | |
| 45.11 | Parts detached for transport (furnish list) | |
| **46.0** | **Proposed filling medium for transportation from works to site** | |
| **47.0** | **Minimum draw bar pull required to move the transformer on level track (kg)** | |
| **48.0** | **Bimetallic Connections** | |
| 48.1 | Normal current rating (A) | |
| 48.2 | Short time current rating (A) | |
| 48.3 | Tensile strength (Kg) | |

| S. No | Description | Particulars |
|---|---|---|
| 48.4 | Maximum temperature limit | |
| 48.5 | Dimensional sketch enclosed indicating tolerances (Yes/No) | |
| 48.6 | Minimum clearance (mm) | |
| | - Phase to Phase | |
| | - Phase to Earth | |
| **49** | Direct Temperature measurement of Windings: No of probes for HV, IV & LV windings. | |

## 3.18. TECHNICAL SPECIFICATION OF SF6 Circuit Breaker (Up to 400 kV)

The intention of this Section of the Specification is to cover design, manufacture, testing at manufacturer's works and supply Circuit Breakers with all fittings and accessories as per BoQ and as specified hereunder.

**3.18.1.0 GENERAL**

**3.18.1.1** The circuit breakers and accessories shall conform to latest revision of IEC: 62271-100, IEC: 62271-1 and other relevant IEC standards except to the extent explicitlymodified in the specification and shall also be in accordance withrequirements specified in GTR.

**3.18.1.2** 420/245/145/72.5kV circuit breakers offered would be of Sulphur hexafluoride (SF6) type and of class C2-M2 as per IEC. The bidder may offercircuit breakers of either live tank type of proven design.

**3.18.1.3** The circuit breaker shall be complete with operating mechanism, common marshalling box, piping, inter-pole cables, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure, platform with ladder for CB, their foundation bolts and all other accessories required for carrying out all the functions of the CB.

All necessary parts to provide a complete and operable circuit breaker installation such as terminal pads, control parts and other devices shall be provided.

**3.18.1.4** Painting shall be done in line with GTR. Paint shade RAL-7032 orsimilar shades can be used for painting. The support structure, platform & ladder of circuit breaker shall be hot dip galvanised. Exposed hardware itemsshall be hot dip galvanised or Electro-galvanised.

**3.18.1.5** The circuit breakers shall be designed for use in the geographic and meteorological conditions as given Below:

| | | | | |
|---|---|---|---|---|
| a) | Peak ambient day temperature in still air | | | : 45°C |
| b) | Minimum night temperatures | | | : 0°C |
| c) | Ground temperatures | | | : 40°C |
| d) | Reference ambient day temperature | | | : 45°C |
| e) | Relative Humidity | a) | Maximum | : 100 % |
| | | b) | Minimum | : 10 % |
| f) | Altitude | | | : Below1000 M above MSL |
| g) | Maximum wind pressure | | | : As per IS: 802 latest codes. |
| h) | Seismic Intensity | | | : ZONE-V as per IS 1893. |

**3.18.1.6** All 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD by using a suitable selector switch irrespective of whether circuit breakers to be supplied are envisaged along with CSD or not as per bid price schedules.

**3.18.2.0 DUTY REQUIREMENTS**

**3.18.2.1** The circuit breakers shall be capable of performing their duties without opening resistors.

**3.18.2.2** The circuit breaker shall meet the duty requirements for any type of fault or fault location and also for line switching when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

**3.18.2.2.1** PRE-INSERTION RESISTER

420kV circuit breakers shall be provided with single step pre- insertion closing resistors (wherever the requirement of PIR is explicitly specified in bid price schedules) to limit the switching surges. The resistance value of pre-insertion resistor and the duration of pre-insertion time isgiven in **clause 3.18.19** of this section. The resistor shall have thermal rating for the following duties:

i) TERMINAL FAULT

Close .... 1 Min .... Open Close Open…..2 min ..... Close ..... 1 Min ..... Open Close Open.

ii) RECLOSING AGAINST TRAPPED CHARGES

Duty shall be the same as under (i) above. The first, third and fourth closuresare to be on de - energised line while second closing is to be made with lines against trapped charge of 1.2 p.u. of opposite polarity.

iii) OUT OF PHASE CLOSING

One closing operation under phase opposition, that is with twice the voltage across the terminals.

iv) No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor support shall perform all these duties without deterioration. Test reports of resistors proving thermal rating for duties specified above shall be furnished during detailed engineering. The calculations shall be provided to take care of the effect of tolerances on resistance values and insertion time.

**3.18.2.3** The breaker shall be capable of:

i) Interrupting the steady and transient magnetizing current correspondingto Power transformers as follows:

| Voltage rating of CB | Type of Transformer | Rating (in MVA) |
|---|---|---|
| 420kV | 400/220kV | 250 to 630 |
| | 400/132kV | 160 to 315 |
| 245kV | 400/220kV | 200 to 630 |
| | 220/132kV | 50 to 200 |
| | 220/66kV | 50 to 200 |
| 145kV | 220/132kV | 50 to 200 |
| | 132/33kV | 10 to 50 |

ii) Interrupting line/cable charging current as per IEC without use of opening resistors. The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of U/√3 and 1.4

iii) Clearing short line fault (kilometric faults) with source impedancebehind the bus equivalent to symmetrical fault current specified.

iii) Breaking 25% of the rated fault current at twice rated voltage underphase opposition condition.

iv) Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e., shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).

v) Circuit breakers shall be able to switch in and out the shunt reactoras detailed below:

| Voltage rating of CB | Reactor Rating (in MVAR) | Max. rise of over voltage (in p.u.) |
|---|---|---|
| 420kV | 50 to 150 | 2.3 |
| 245kV | 25 to 50 | 2.3 |

a. Capability of 400 kV circuit breakers to interrupt inductive current below 100 A without giving rise to overvoltage more than 2.3 p.u. (As specified in IEC-62271-110) shall be validated by carrying out the simulation study/analysis (EMTP/PSCAD) by modeling an equivalent circuit comprising all circuit component i.e. Inductance of Shunt Reactor, Stray capacitance of Shunt Reactor, Circuit Breaker, Stray capacitance of Bus Connection, Capacitance of grading Capacitor, inductance of neutral grounding reactor, Network Thevenin's equivalent, any other series/parallel inductance/capacitance connected to simulate theactual inductive load switching.

b. Current chopping capability (chopping number) of circuit breakeras per IEC-62271-306 to be figured out from actual Laboratory test and / or field test report and same Current chopping capability (chopping number) shall be used in above said simulation study/analysis.

c. To validate the results of above said simulation study/analysisreport, the same study shall be carried out for capability of tested circuit breaker and the study/analysis results shall be comparable with actual Laboratory test and / or field test reports.

d. Laboratory test/ field test reports shall be submitted for 400 kV CBs in case there is change in design including change in following:

**i.** Different short circuit current capability

**ii.** Different model/type

vi) The breakers shall also withstand the voltages specified under **clause 3.18.19** of this section.

**3.18.3 CONTROLLED SWITCHING DEVICE (CSD):**

Circuit Breakers shall be equipped with controlled switching device with consequent optimization of switching behavior, when used in:

**3.18.3.1** Switching of transformer (from 400kV side circuit breakers only)

**3.18.3.2** Switching of shunt Reactor

The CSD shall be provided in Circuit breaker of switchable line reactor bay and in Main & Tie Bay circuit breakers of Transformers, line with non- switchable line reactors and Bus reactors. The CSD shall be supplied as per bid price schedules.

**3.18.3.3** Technical Requirement for controlled switching device:

a) The CSD shall be designed to operate correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified in section - GTR.

b) The CSD shall meet the requirements of IEC-61000-4-16 class IV for HF disturbance test (for short and long durations both) and fast transient test shall be as per IEC-61000-4-4 level IV and insulation test as per IEC 60255–5.

c) The CSD shall have functions for switching ON & OFF the circuit breakers.

d) The CSD shall get command to operate the breakers manually. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs & CVTs for the purpose of calculation of optimum moment of the switching the circuit breaker and issue command to circuit breaker to operate.

e) The CSD shall also have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing theswitching command. In calculation of next operating time of the breaker, the CSD must consider all factors that may affect the operating time of thebreaker such as, but not limited to, ambient temperature, control voltage variation, SF6 gas density variations etc. Schematic drawing for this purpose shall be provided by the contractor. The accuracy of the operating time estimation by the controller shall be better than ± 0.5 ms.

f) The CSD should have display facility at the front for the display ofsettings and measured values.

g) The CSD shall be PC compatible for the setting of various parameters and down loading of the settings and measured values, date, time of switching etc. Window based software for this purpose shall be supplied by the contractor to be used on the owner's PC.

h) The controller shall be suitable for current input of 1 ampere from the secondary of the CTs. and 110 V (Ph to Ph) from the CVTs. The CSDshall withstand transient and dynamic state values of the current from the secondary of the CTs and CVTs.

i) The CSD shall have time setting resolution of 0.1 ms or better.

j) The CSD shall have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room. Necessary details shall be worked out during engineering of the scheme.

k) The CSD shall also record and monitor the switching operations and make adjustments to the switching instants to optimize the switching behavior as necessary. It shall provide self-diagnostic facilities, signaling of alarms and enable downloading of data captured fromthe switching events.

l) The provision for bypassing the Controlled switching device shall beprovided through BCU and SCADA both so that whenever, the CSD is not healthy due to any reason (including auxiliary supply failure), uncontrolled trip/close command can be extended to the circuit breaker. Alternatively, in case of any non-operation of the CSD after receiving a close/trip command after a pre-determined time delay, theCSD should automatically be bypassed so as to ensure that the trip and close commands are extended to the Trip/Close coils through subsequentcommand.

m) The CSD shall be provided with a communication port to facilitate online communication of the CSD with Substation automation system directly on IEC 61850 protocols. If the CSD does not meet the protocols of IEC 61850, suitable gateway shall be provided to enable the communication of CSD as per IEC 61850.

### 3.18.4 TOTAL BREAK TIME

The total break time as specified under this section shall not be exceeded under any of the following duties:

**3.18.4.1** Test duties T10, T30, T60, T100a, and T100s (with TRV as per IEC:62271-100)
**3.18.4.2** Short line fault L75, L90 (with TRV as per IEC: 62271-100)

The total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the effect of non-simultaneity between contacts within a pole or between poles shall be brought out to establish guaranteed total break time.

The values guaranteed shall be supported with the type test reports.

### 3.18.5 CONSTRUCTIONAL FEATURES

The features and constructional details of circuit breakers shall be inaccordance with requirements stated hereunder:

**CONTACTS**

**3.18.5.1** The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero-gauge pressure of SF6 gas due to the leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e., 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric with stand test conducted for a duration of at least 15 minutes is acceptable).

**3.18.5.2** If multi-break interrupters are used, these shall be so designed and augmentedthat a uniform voltage distribution is developed across them.
Calculations/ test reports in support of the same shall be furnished. The thermal and voltage withstand rating of the grading elements shall be adequate for the service conditions and duty

specified.

**3.18.6 The SF6 Circuit Breaker shall meet the following additional requirements:**

a) The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a minimumpossibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.

b) All gasketed surfaces shall be smooth, straight and reinforced, if necessary, to minimise distortion and to make a tight seal, the operatingrod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed during the warrantee period. In case the leakage under the specified conditions is found to be greater than 0.5% per year after commissioning of circuit breaker during the warrantee period, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during the warrantee period.

c) In the interrupter assembly there shall be an absorbing product box to minimise the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF6 gas decomposition products.

d) Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 420 & 245 kV CBs) and the SF6 density of each pole shall be monitored individually. For CBs of voltage class of 145 kV or less, a common SF6 scheme/density monitor shall be acceptable.

e) The dial type SF6 density monitor shall be adequately temperaturecompensated to model the pressure changes due to variations in ambienttemperature within the body of circuit breaker as a whole. Separate density monitors and dial type temperature compensated pressure gauge is also acceptable. The density monitor shall have graduated scale and it shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by providing suitable interlocked non return valve coupling.

f) Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.

g) Sufficient SF6 gas (including that will be required for gas analysis during filling) shall be provided to fill all the circuit breakers being supplied. Spare gas shall be supplied in separate unused cylinders asper requirement specified in BPS.

h) Provisions shall be made for attaching an operational analyser to recordcontact travel, speed and making measurement of operating timings, preinsertion timings of closing resisters if used, synchronization of contacts in one pole.

i) The CO (Close-open) operation and its timing shall be such as to ensure complete travel/insertion of the contact during closing operation andthen follow the opening operation.

**3.18.7 SULPHUR HEXAFLUORIDE GAS (SF6 GAS)**

**3.18.7.1** The SF6 gas shall comply with IEC 60376 and shall be suitable in all respects for use in the switchgear under the operating conditions.

**3.18.7.2** The high-pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations. SF6 gas shall be supplied (in returnable cylinders) forall circuit breakers. However, SF6 gas for spare circuit breakers and mandatory spare quantity of SF6 gas shall be supplied in non- returnable cylinders.

**3.18.7.3** Test: SF6 gas shall be tested for purity, dew point, air, hydro-soluble fluorides and water content as per IEC 60376 and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas and Material safety datasheet shall be provided. Gasbottles should be checked for leakage during receipt at site.

**3.18.8 INSULATORS**

**3.18.8.1** The porcelain/polymer of the insulators shall conform to the requirements stipulated under Section-GTR.

**3.18.8.2** The mechanical characteristics of insulators shall match with the requirements specified under this section.

**3.18.8.3** All porcelain & polymer hollow column insulators shall conform to IEC-62155 & IEC-61462

respectively.

**3.18.8.4** Hollow Porcelain/polymer for pressurized columns/chambers should bein one integral piece in green and fired stage.

### 3.18.9 SPARE PARTS AND MAINTENANCE EQUIPMENT

The bidder shall include in his proposal, spare parts and maintenance equipment in accordance with BPS. Calibration certificates of each maintenance equipment shall be supplied along with the equipment.

### 3.18.10 OPERATING MECHANISM AND CONTROL

General Requirements

**3.18.10.1** Circuit breaker shall be operated by spring charged mechanism. The mechanism box shall meet the requirements of IP-55.

**3.18.10.2** The operating mechanism box shall be strong, rigid, rebound free and shall be readily accessible for maintenance.

**3.18.10.3** The mechanism shall be anti-pumping and trip free under every method of closing.

**3.18.10.4** The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause unwanted trip or closing operation of the Circuit Breaker

**3.18.10.5** A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the common marshalling box.

**3.18.10.6** Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned orlocked to prevent loosening or changing adjustment with repeated operationof the breaker.

**3.18.10.7** The contractor shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker. The instruction manuals shall contain exploded diagrams with complete storage, handling, erection, commissioning, troubleshooting, servicing and overhauling instructions.

**3.18.10.8** Size of common marshalling Box shall be such that adequate space is available for working in the panel and all wiring shall be routed through non-inflammable wire troughs with covers.

**3.18.10.9** Operating mechanism and Marshalling box should be provided withspace heater with thermostat, CFL/LED lamp and AC point /Socket.

### 3.18.11 Control

**3.18.11.1** The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

**3.18.11.2** Each breaker shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources.

**3.18.11.3** The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose, a local/remote selector switch and close and trip control switch/push buttons shall be provided in the Breaker common marshalling box.

**3.18.11.4** The trip coils shall be suitable for trip circuit supervision during both openand close position of breaker.

**3.18.11.5** Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip coil and associated circuits shall operate correctly under all operating conditions of thecircuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage. However, even at 50% of rated voltage the breaker shall be able to open. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on outdoor circuit breakers shall be clearly brought out during detailed engineering.

**3.18.11.6** In trip and closing circuits, relays/relay contacts shall preferably be used instead of contactors.

**3.18.11.7** Controlled switching scheme/device, wherever required shall be considered as integral part of CB and shall be commissioned along with CB.

**3.18.11.8** Density Monitor contacts and pressure switch contacts shall be preferably suitable for direct use as permissive in closing and tripping circuits. The devices shall provide continuous & automatic monitoring of the state of the gas as follows:

**3.18.11.8.1** 'Gas Refill' level

This contact will be used for remote indication/ to annunciate the needfor gas refilling.

**3.18.11.8.2** 'SF6 gas density Low' Alarm level - 1

This contact will be used for remote indication/ to annunciate the needfor the urgent gas refilling.

**3.18.11.8.3** 'SF6 gas density Low' Alarm level - 2

This contact will be used to annunciate the need for gas refilling under emergency or trip the Circuit Breaker.

**3.18.11.8.4** 'Breaker Block' level

This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the breaker block contact shall operate & the tripping & closing circuit shall be blocked.

It shall be possible to test all gas monitoring relays/devices without de- energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

The density monitor shall be placed suitably inclined in such a way so that thereadings are visible from ground level with or without using binoculars. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail-safe logic/schemes are to be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations andoperation lockout in case of D.C. failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit Breaker.

**3.18.11.9** The auxiliary switch of the breaker shall be positively driven by the breakeroperating rod.

**3.18.12 Spring operated mechanism:**

a) Spring operated mechanism shall be complete with motor as per manufacturer practice. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence ofthe closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall be automatically charged for the next operation and an indication of this shall be provided in the local and remote-control cabinet.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to preventdischarging of closing springs when the breaker is already in the closed position.

h) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

i) The spring charging failure alarm shall be provided with a time delay relay having setting

range from 0-1minute.

j) Separate MCBs shall be provided for each spring charging motor and the rating of MCBs shall be suitably selected to match the starting, running and stalling time.

k) An overload relay shall be provided for protection of the spring charging motor.

**3.18.13 SUPPORT STRUCTURE**

**3.18.13.1** The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

**3.18.13.2** Ladder and Maintenance platform for 400kV Circuit breaker:

A suitable ladder with the safety cage and a free-standing maintenance platform with railing for each pole of the circuit breaker shall be supplied along with the equipment and its supportstructure. The platform shall be suitable for maintenance personnelto stand and carryout the activities along with the tools and plant.

The ladder cum maintenance platform shall be designed as a free-standing structure without taking any support from the main circuit breaker structure. The ladder having height more than 3.0mshall have at least 15-degree slope and is to be provided with safety guard above 2.0m level. All structural steel for the platform shall beas per IS: 2062 and to be galvanized. For 220kV, 132kV circuit breakers a suitable platform cumladder shall be provided as per manufacturer design.

**3.18.14 TERMINAL CONNECTOR PAD**

The circuit breaker terminal pads shall be made up of high-quality electrolyticcopper or aluminium and shall be conforming to Australian Standard AS- 2935 or equivalent standard for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

INTER-POLE CABLING

a) All cables to be used by contractor shall be armoured and shall be as per IS – 1554/ IEC-60502 (1100 Volts Grade). All cables within & between circuit breaker poles and its marshaling box and up to the controlled switching device is included in the scope of work. Special cables like screened cable if required for Circuit Breaker, temperature Transducer/CB Status Signals for CSD and its associated C&R panel shall be laid in 50mm diameter PVC pipe. Suitable supports for PVC pipe shall be included in the scope of Supply.

b) Only stranded conductor shall be used. Minimum size of the conductor for inter-pole control wiring shall be 2.5 sq.mm. Copper.

c) The cables shall be with oxygen index Minimum 29 and temperature index as 250$^{O}$C as per relevant standards.

d) Separate cables shall be used for AC, DC-I, DC-II and selected DC.

e) All inter-pole cabling of Circuit breakers and up to common marshallingbox shall be done by plug-in type arrangement. Suitable removable type encasing cover shall be provided in case plug-in type connection arrangement is provided exterior side of LCC/MB. The plug-in typecable termination shall be conforming to IP-67 as per IEC60529. Cable sealing arrangement shall be provided (as per requirement) to avoid entry of moisture etc.

f) Vertical run of cables to the operating mechanism box shall be properly supported by providing the perforated closed type galvanized cable tray (Cable tray also to be supplied along with the Circuit Breaker) to befixed as an integral part of the structures. The load of the cable shall not be transferred to the mechanism box/plug-in type terminal arrangement in any circumstances. Hanging or loose run of cable is not permitted. The drawing of cable tray including fixing arrangement shall be incorporated in the GA drawing of CB also.

g) Wiring shall be done with stud type terminals and ring type lugs. More than two wires shall not be connected on each side of terminal.

**3.18.15 FITTINGS AND ACCESSORIES**

Following is list of some of the major fittings and accessories to be furnished by Contractor in the common marshalling box. Number and exact location of these parts shall be indicated in the drawing.

**3.18.15.1** Cable glands (Double compression type), Lugs, Ferrules etc.
**3.18.15.2** Local/remote changeover switch.
**3.18.15.3** Operation counter
**3.18.15.4** Control switches to cut off control power supply.
**3.18.15.5** Fuses/MCBs as required.
**3.18.15.6** The number of terminals provided shall be adequate enough to wire outall contacts and control circuits plus 24 terminals spare for future use.
**3.18.15.7** Anti-pumping relay.
**3.18.15.8** Pole discrepancy relay (for electrically ganged CBs).
**3.18.15.9** D.C. Supervision relays.
**3.18.15.10** Rating plate description in accordance with IEC incorporating year ofmanufacture.
**3.18.15.11** Controlled switching accessories like sensors, timers, relays etc. (asapplicable)
**3.18.15.12** Transducers/Fixtures required for travel measurement shall be supplied by CB manufacturer. The complete set of Transducers/Fixtures for measurement of complete 3-phase CB shall be supplied for each station. Further, one set of gas filling adopter (Including coupling, regulator, connecting hose pipe up to ground level) shall be supplied as per BPS.

### 3.18.16 ADDITIONAL DATA TO BE FURNISHED

**3.18.16.1** Drawing, showing contacts in close, arc initiation, full arcing, arc extinction and open position.
**3.18.16.2** The temperature v/s pressure curves for each setting of density monitor along with details of density monitor.
**3.18.16.3** Method of checking the healthiness of voltage distribution devices (condensers) provided across the breaks at site.
**3.18.16.4** Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.
**3.18.16.5** Maximum non-simultaneity between contacts, between poles and effect of the same on the guaranteed total break time.
**3.18.16.6** Sectional view of non-return couplings used for SF6 pipes.
**3.18.16.7** Details & type of filters used in interrupter assembly and also the operating experience with such filters.
**3.18.16.8** Details of SF6 gas:
i) The test methods used in controlling the quality of gas used in thecircuit breakers particularly purity and moisture content.
ii) Proposed tests to assess the conditions of the SF6 within a circuit breaker after a period of service particularly with regard to moisture contents of the gas.
**3.18.16.9** Shall furnish curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage.
**3.18.16.10** Detailed literature and schematic diagrams of switching mechanism for closing resistor showing the duration of insertion shall also be furnishedalong with the calculations in respect of thermal rating of resistors for the duties specified in this section in case of 420 kV circuit breakers.
**3.18.16.10** All duty requirements as applicable to 420 kV, 245 kV & 145 kVCBs specified under Clause 3.18.2.0 of this section shall be provided with the support of adequate test reports.

### 3.18.17 TESTS

**3.18.17.1** In accordance with the requirements stipulated under Section-GTR the circuit breaker along with its operating mechanism shall conform to the type tests as per IEC: 62271-100.
**3.18.17.2** The type test reports as per IEC and the following additional type test reportsshall also be submitted for purchaser's/employer's review:

i. Corona extinction voltage test
ii. Out of phase closing test as per IEC: 62271-100.
iii. Line charging interrupting current for proving parameters as per **clause 3.18.19** of this section.
iv. Test to demonstrate the Power Frequency withstand capability of breaker in open condition

at Zero Gauge pressure and at lockout pressure (Ref. **Clause 3.18.5.1**).

v. Seismic withstand test inunpressurised condition.

vi. Verification of the degree of protection.

vii. Low temperature test (applicable only for minimum ambient temperatures of less than (-) 10 deg. C application purpose) and High temperature test. Contractor can also submit the field performance report in line with IEC stipulations.

viii. Static Terminal Load test.

ix. Critical Currents test (if applicable).

x. Switching of Shunt Reactors. Test reports shall be submitted as per IEC. Calculations shall be submitted for meeting the requirements of **clause 3.18.2.3(v)** of this section.

xi. Circuit breakers meant for controlled switching shall conform to requirements of IEC/TR-62271 – 302. The contractor shall submittest reports to demonstrate that the offered CB conforms to the requirements of performance verification tests and parameter definition tests as per IEC/TR 62271-302. The contractor shallalso furnish the report for the re-ignition free arcing window for switching 3-phase shunt reactor as demonstrated in the shuntreactor switching test.

**3.18.18 Routine Tests**

Routine tests as per IEC:62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, thefollowing tests shall also be performed.

**3.18.18.1** Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto reclosing and trip free operation under normal as well as limiting operating control voltage conditions. The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be arranged by the contractor at his own cost.

**3.18.18.2** During testing of CB, dynamic contact resistance measurement (DCRM) shall be carried out for close-open (CO) operations with delay of 300ms between close and trip operations. Minimum 100A current shall be injected for DCRM test. Travel characteristics, injected current, trip/close coil current shall also be recorded along with DCRM test.

**3.18.18.3** Routine tests on Circuit breakers with Controlled switching deviceas per IEC/TR 62271-302.

**3.18.18.4** Tan delta and Capacitance measurement for grading capacitors atrated voltage and also at 10kV (for reference).

### 3.18.19 TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

(In addition to those indicated in section-GTR)

| Sl. no. | Parameter | 400kV system | 220kV system | 132 kV system |
|---|---|---|---|---|
| 1. | Rated voltage (Umax) kV (rms) | 420 | 245 | 145 |
| 2. | Rated frequency (Hz) | 50 | 50 | 50 |
| 3. | No. of poles | 3 | 3 | 3 |
| 4. | Type of circuit breaker | SF6 gas insulated | SF6 gas insulated | SF6 gas insulated |
| 5. | Rated continuous current (A) at an ambient temperature of $50^0$C | 4000 | 3150 | 3150 |
| 6. | Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening time under operating conditions specified. | 63kA | 50 kA | 40 kA |
| 7. | Symmetrical interrupting capability kA (rms) | 63 | 50 | 40 |
| 8. | Rated short circuit making current kAp | 157.5 | 125 | 100 |
| 9. | Short time current carrying capability kA (rms) | 63 for three second | 50 for three second | 40 for three second |
| 10. | Out of phase breaking current carrying capability kA (rms) | 15.75 | **As per IEC** | **As per IEC** |
| 11. | Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before | 600 | As per IEC | As per IEC |
| | opening equal to the product of U/√3 and 1.4 as per IEC-62271-100 | | | |
| 12. | First pole to clear factor | 1.3 | 1.3 | 1.3 |
| 13. | Temperature rise over an ambient temperature of $50^0$C | As per IEC:62271-100 | As per IEC: 62271-100 | As per IEC:62271-100 |
| 14. | Rated break time as IEC (ms) | 40 | 60 | 60 |
| 15. | Total break time (ms) | 45 | 65 | 65 |

| | | | | |
|---|---|---|---|---|
| 16. | Total closing time (ms) | Not more than 150 | Not more than 150 | Not more than 150 |
| 17. | Operating mechanism or a combination of these | Spring | Spring | Spring |
| 18. | Rated operating duty cycle | O-0.3s-CO-3 min-CO | O-0.3s-CO-3 min-CO | O-0.3s-CO-3 min-CO |
| 19. | Reclosing | Single phase &Three phaseauto reclosing. | Single phase &Three phase auto reclosing. | Three phaseauto reclosing. (Single phase auto reclosing if specified in section-project) |
| 20. | Pre-insertion resistor requirement | As per BPS | NA | NA |
| i) | Rating (ohms) | 400(max.) with tolerance as applicable | NA | NA |
| ii) | Minimum electrical (mechanical insertion time +pre-arcing time) pre-insertion time (ms) | 8 | NA | NA |
| iii) | Opening of PIR contacts | PIR contactsshould open immediately after closingof main contacts OR At least 5 ms prior to opening of main contactsat rated air/gas pressure where the | NA | NA |
| | | PIR contacts remain closed | | |
| 21. | Max. difference in the instants of closing/openingof contacts (ms) between poles at rated control voltage and rated operating& quenching media pressures | 2.5(within a pole) 3.3(opening) 5.0(closing) | 3.3(opening) 5.0(closing) | 3.3(opening), 3.3(closing) |
| 22. | Maximum allowable switching over voltage under any switching condition | 2.3 p.u. | As per IEC | As per IEC |
| 23. | Trip coil and closing coil voltage with variation as specified | 220V DC or 110VDC | 220V DC or 110V DC | 220V DC or 110V DC |
| 24. | Noise level at base and up to 50 m distance from base of circuit breaker | 140dB (max.) | 140dB (max.) | 140dB (max.) |
| 25. | Rating of Auxiliary contacts | 10A at 110/220V DC | 10A at 110/220V DC | 10A at 110/220V DC |

| | | | | |
|---|---|---|---|---|
| 26. | Breaking capacity of Aux. Contacts | 2A DC withcircuit time constant not less than 20ms | 2A DC withcircuit time constant not less than 20ms | 2A DC withcircuit time constant not less than 20ms |
| 27. | **Rated insulation levels** | | | |
| i) | Full wave impulse withstand (1.2 /50 µs) between line terminals and ground | 1425 kVp | 1050 kVp | 650 kVp |
| ii) | Full wave impulse withstand (1.2 /50 µs) between terminals with circuit breaker open | 1425 kVp impulse on one terminal& 240 kVp power frequency voltage of opposite polarity on the other terminal | 1050 kVp | + 650kVp |
| iii) | Rated switching impulse withstand voltage (250/2500 µs) Dry & wet between line terminals and ground | +1050 kVp . | NA | NA |
| iv) | Rated switching impulse withstand voltage (250/2500 µs) Dry &wetBetween terminals with circuit breaker open | 900 kVp impulse on one terminal& 345 kVp power frequency voltage of opposite polarity on the other terminal | NA | NA |
| v) | One minute power frequency dry withstand voltage between line terminals and ground | 520 kV rms. | 460 kV rms. | 275 kV rms |
| vi) | One minute power frequency dry withstand voltage between terminals with circuit breaker open | 610 kV rms. | 460 kV rms. | 275 kV rms |
| 28. | Minimum corona extinction voltage with CB in all positions | 320kV rms | 156 kV rms | 92 kV rms |
| 29. | Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz (Micro volts) | 1000 µV (at 266kVrms) | 1000 µV (at 156kVrms) | 500µV (at 92kVrms) |
| 30. | Minimum Creepage distance* | | | |
| i) | Phase to ground (31mm/kV) | 13020mm | 7595mm | 4495mm |
| ii) | Between CB terminals | 13020mm | 7595mm | 4495mm |
| 31. | System neutral earthing | Effectively earthed | | |
| 32. | Rated terminal load | As per IEC or as per the value calculated based on specific switchyard layout requirement, whichever is higher. | | |

| | | |
|---|---|---|
| 33. | Auxiliary contacts | Besides requirement of technical specification, the manufacturer/contractorshall wire up 10 NO + 10 NC contacts exclusively for purchaser's use and wired up to common marshalling box. |
| 34. | No. of terminals in common marshalling box | All contacts & control circuits to be wired out up to common marshallingbox + minimum 24 terminals exclusively for purchaser's future use |
| 35. | Seismic level | 0.5g horizontal for the site location under the Zone-V as per IS-1893<br>0.3g horizontal for the site location under other than the Zone-V as per IS-1893 |

**3.18.20 PRE-COMMISSIONING TESTS**

An indicative list of tests is given below. All routine tests except power frequencyvoltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

2.21.1 Insulation resistance of each pole.
2.21.2 Check adjustments, if any suggested by manufacturer.
2.21.3 Breaker closing and opening time.
2.21.4 Slow and Power closing operation and opening.
2.21.5 Trip free and anti-pumping operation.
2.21.6 Minimum pick-up voltage of coils.
2.21.7 Dynamic Contact resistance measurement.
2.21.8 Functional checking of control circuits interlocks, tripping throughprotective relays and auto reclose operation.
2.21.9 Insulation resistance of control circuits, motor etc.
2.21.10 Resistance of closing and tripping coils.
2.21.11 SF6 gas leakage check.
2.21.12 Dew Point Measurement
2.21.13 Operation check of pressure switches and gas density monitor duringgas filling.
2.21.14 Checking of mechanical 'CLOSE' interlock, wherever applicable.
2.21.15 Testing of grading capacitor.
2.21.16 Resistance measurement of main circuit.
2.21.17 Checking of operating mechanisms
2.21.18 Check for annunciations in control room.
2.21.19 Point of wave switching test (wherever applicable)

The contractor shall ensure that erection, testing and commissioning of circuit breaker shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

**3.18.21 ACTIONS REQUIRED FOR DEFECTS OBSERVED DURING DEFECT LIABILITY PERIOD**

The actions required to be taken by contractor in case of defects observed in AIS type Circuit Breakers of ratings 132kV & above during the warranty period (defect liability period) shall be as per following. Further, the replaced/repaired/ refurbished equipment (or part of equipment) shall have warranty in line with the GCC clause in SCC.

| Sl.no. | Nature of problem | Corrective measures to be taken by contractor |
|---|---|---|
| 1. | Blasting of interrupter, PIR, pole column, | Replacement of compete CB pole Including SF6 gas |
| | a. Abnormal DCRM and Travel Measurement<br>b. Contact assembly and internal component damage, misalignment not leading to complete failure of interrupter/ PIR | Repair/replacement of affected assembly/ component based on repair procedure approved by QA |
| 2. | Crack in insulator, cementing joint of interrupter, PIR, pole column | Replacement of affected part |
| 3. | SF6 gas leakage from sealing and bolted joints.SF6 gas leakage detectable by any Leakage Detection Method | Rectification by replacement of gasket, O-ring, sealing, Interrupter or affected part to be replaced etc.<br>If unable to arrest the leakage in 02 attempts, replacement of interrupter/ column |
| 4. | SF6 gas low dew point: > (-)35 deg C at atmospheric pressure. | Re-conditioning of gas.<br>If does not improve, complete evacuationof CB, replacement filter material and gas |
| 5. | Oil leakage of grading capacitor<br>Change in Capacitance value beyond +/- 5 % w.r.t. to value of Capacitance obtained at site during pre-commissioning test. | Replacement or Refurbishment of grading capacitor |
| 6. | Pole/ break discrepancy (during O&M)<br>Limits:<br>Break to Break (Opening/Closing): max. 2.5 ms<br>Phase to Phase (Opening): max. 3.33 ms<br>Phase to Phase (Closing): max 5 ms | Rectification/replacement of affected parts |
| 7. | Static Contact Resistance: increase >50% from factory/ pre-commissioning value or >75 micro-ohm/ break whichever is lower | Rectification/Replacement of pole |
| 8. | Drive mechanism assembly failure | Rectification/ Replacement of affected part |
| 9. | Trip/ close coil, density monitor, relays and contactors and components of common MB | Replacement of affected part |

**Note: 1) Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.**

# 3.19 TECHNICAL SPECIFICATION FOR 220 kV & 132 kV CURRENT TRANSFORMERS (AIS)

### 3.19.1 SCOPE

This Section of the Specification covers general requirements for design, engineering, manufacture, assembly and testing at manufacturer's works of 220 kV and 132 kV outdoor Current Transformers.

### 3.19.2 STANDARDS

**3.19.2.1** The equipment covered by this specification shall, unless otherwise stated be designed, constructed and tested in accordance with the latest revisions of relevant Indian Standards and shall conform to the regulations of local statutory authorities.

**3.19.2.2** In case of any conflict between the Standards and this specification, this specification shall govern.

**3.19.2.3** The current transformer shall comply also with the latest issue of the following Indian standard.

| | | |
|---|---|---|
| (i) | IS: 2705(Part-I) | Current transformers: General requirement. |
| (ii) | IS: 2705(Part-II) | Current transformers: Measuring Current transformers |
| (iii) | IS: 2705(Part-III) | Current transformers: Protective Current transformers |
| (iv) | IS: 2705(Part-IV) | Current transformers: Protective Current transformers for special purpose application. |

### 3.19.3 GENERAL REQUIREMENTS

**3.19.3.1** The cores of the instrument transformers shall be of high grade, non-aging CRC steel of low hysteresis loss and high permeability.

**3.19.3.2** Current transformers shall be of Live Tank design.

**3.19.3.3** The instrument transformers shall be truly hermetically sealed to completely prevent the oil inside the tank coming into contact with the outside temperature. To take care of oil volume variation the tenderer is requested to quote the current transformers with stainless steel diaphragm (bellow).

**3.19.3.4** The instrument transformers shall be completely filled with oil.

**3.19.3.5** A complete leak proof secondary terminal arrangement shall be provided with each instrument transformers, secondary terminal shall be brought into weather, dust and vermin proof terminal box. Secondary terminal boxes shall be provided with facilities for easy earthing, shorting, insulating and testing of secondary circuits. The terminal boxes shall be suitable for connection of control cable gland. IP rating of terminal box shall be IP 55. Spare terminals shall be provided.

**3.19.3.6** All instrument transformers shall be of single-phase unit.

**3.19.3.7** The instrument transformers shall be so designed to withstand the effects of temperature, wind load, short circuit conditions and other adverse conditions.

**3.19.3.8** All similar parts, particularly removable ones, shall be interchangeable with one another.

**3.19.3.9** All cable ferrules, lugs, tags, etc. required for identification and cabling shall be supplied complete for speedy erection and commissioning as per approved schematics.

**3.19.3.10** The instrument transformers shall be designed to ensure that condensation of moisture is controlled by proper selection of organic insulating materials having low moisture absorbing characteristics.

**3.19.3.11** All steel work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint.

### 3.19.4 INSULATING OIL

The quantity of insulating oil for instrument transformers and complete specification of oil shall be stated in the tender. The insulating oil shall conform to the requirement of latest edition of IS: 335

### 3.19.5 COMMON MARSHALLING BOXES (shall be supplied by CT manufacturer)

**3.19.5.1** The outdoor type common marshalling boxes shall conform to the latest edition of IS 5039 and other general requirements specified hereunder.

**3.19.5.2** The common marshalling boxes shall be suitable for mounting on the steel mounting structures of the instrument transformers.

**3.19.5.3** One common marshalling box shall be supplied with each set of instrument transformers. The marshalling box shall be made of sheet steel and weather-proof. The thickness of sheet steel used shall be not less than 3.0 mm. It is intended to bring all the secondary terminals to the common marshalling. The marshalling box shall be of hot dipped galvanized steel.

**3.19.5.4** The enclosures of the common marshalling boxes shall provide a degree of protection of not less than IP 55 (As per IS 2147).

**3.19.5.5** The common marshalling boxes shall be provided with double hinged front doors with pad locking arrangement. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement.

**3.19.5.6** Each marshalling box shall be fitted with terminal blocks made out of moulded non-inflammable plastic materials and having adequate number of terminals with binding screws washers etc. Secondary terminals of the instrument transformers shall be connected to the respective common marshalling boxes. All out going terminals of each instrument transformer shall terminate on the terminal blocks of the common marshalling boxes. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminals.

**3.19.5.7** Each terminal shall be suitably marked with identification numbers. Not more than two wires shall be connected to any one terminal. At least 20 % spare terminals shall be provided over and above the required number.

**3.19.5.8** All terminal strips shall be of isolating type terminals and they will be of minimum 10 A continuous current rating.

**3.19.5.9** All cable entries shall be from bottom. Suitable removable gland plate shall be provided on the box for this purpose. Necessary number of cable glands shall be supplied fitted on to this gland plate. Cable glands shall be screw on type and made of brass.

**3.19.5.10** Each common marshalling box shall be provided with two numbers of earthing terminals of galvanised bolt and nut type.

**3.19.5.11** All steel, inside and outside work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint. The colour of finishing paint shall be as follows: -

i) Inside: Glossy White
ii) Outside: Light Grey (Shade No. 697 of IS: 5)

### 3.19.6 BUSHINGS AND INSULATORS

**3.19.6.1** Bushings and Insulators shall be of Porcelain, Solid core type. Porcelain used for the manufacture of bushings and insulators shall be homogeneous, free from defects, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

**3.19.6.2** Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. Bushings shall be designed to have sufficient mechanical strength and rigidity for the conditions under which they will be used. All bushings of identical ratings shall be interchangeable.

**3.19.6.3** Puncture strength of bushings shall be greater than the dry flashover value. When operating at normal voltage, there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the bushings when operating at the normal rated voltage.

**3.19.6.4** The design of bushing shall be such that the complete bushing is a self-contained unit and no audible discharge shall be detected at a voltage up to a working voltage (Phase Voltage) plus 10%. The minimum creepage distance for severely polluted atmosphere shall be 31 mm/KV.

**3.19.6.5** Sharp contours in conducting parts should be avoided for breakdown of insulation. **The insulators shall be capable to withstand the seismic acceleration of 0.5 g in horizontal direction and 0.6g in vertical direction.**

**3.19.6.6** Bushings shall satisfactorily withstand the insulation level specified in data sheet.

**3.19.6.7** Rain shed/drain cover/dome shall be present in CT.

**3.19.6.8** Bellow level indicator shall be present in CT.

**3.19.6.9 Nitrite butyl rubber/Neoprene gaskets shall be used.**

### 3.19.7 TESTS

**3.19.7.1 Routine/Acceptance Tests (all units)**

All routine tests shall be carried out in accordance with relevant Standards. All routine/acceptance tests shall be witnessed by the Employer/his authorised representative.

**3.19.7.2 Type Tests:** The bidder shall furnish type test certificates and results for the all tests as per relevant Standards along with the bid for current and potential transformers of identical design.
Type test certificates so furnished shall not be older than 5 (five) years as on date of Bid opening.
**QAP:** QAP shall be submitted.

**3.19.8 NAME PLATES**

**3.19.8.1** All equipment shall have non-corrosive name plates fix at a suitable position indelibly mark with full particular there on in accordance with the standard adapted. Thickness (1mm), purchase order, project name, serial no etc. shall be present in the Name plate.

**3.19.9 MOUNTING STRUCTURES**

**3.19.9.1** All the equipment covered under this specification shall be suitable for mounting on steel structures. Supply of mounting structures is also in the scope of this tender.

**3.19.9.2** Each equipment shall be furnished complete with base plates, clamps, and washers etc. and other hardware ready for mounting on steel structures.

**3.19.10 SAFETY EARTHING**

**3.19.10.1** The non-current carrying metallic parts and equipment shall be connected to station earthing grid. For these two terminals suitable for 40mm X 10mm GI strip shall be provided on each equipment.

**3.19.11 TERMINAL CONNECTORS (Shall be under manufacturer scope)**

**3.19.11.1** The equipment shall be supplied with required number of terminal connectors of approved type suitable for ACSR. The type of terminal connector, size of connector, material, and type of installation shall be approved by the Employer, as per installation requirement while approving the equipment drawings. No part of a clamp shall be less than 12mm. thick.

**3.19.12 PRE-COMMISSIONING TESTS**

**3.19.12.1** Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) **Current Transformers**
- (i) Insulation Resistance Test for primary and secondary.
- (ii) Polarity test.
- (iii) Ratio identification test - checking of all ratios on all cores by primary injection of current.
- (iv) Dielectric test of oil (wherever applicable).
- (v) Magnetising characteristics test.
- (vi) Tan delta and capacitance measurement
- (vii) Secondary winding resistance measurement
- (viii) Contact resistance measurement (wherever possible/accessible).

**3.19.13 TECHNICAL DATA SHEET FOR CURRENT TF**

**3.19.13.1** For 245/145/36 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired up to the terminal blocks.

**3.19.13.2 TYPE AND RATING:**

All instrument transformer shall be outdoor type, single phase, oil immersed, self-cooled suitable for mounting on steel structure. The instrument transformer shall have the following ratings and particulars.

## REQUIREMENTS FOR 245 KV CURRENT TRANSFORMER

| No. of Cores | Core No. | Appli-cation | Current ratio | Output burden (VA) | Accuracy class | Min. knee pt.volt-age (Vk) | Max. CT sec.wdg. resist-ance(ohms) | Max. Excit-ation cur-rent at Vk (in mA) |
|---|---|---|---|---|---|---|---|---|
| 5 | 1 | BUS DIFF CHECK | 1600-800/1 | - | **PX** | 1600/800 | 8/4 | 25 on 1600/1 Tap; 50 on 800/1 Tap |
| | 2 | BUS DIFF MAIN | 1600-800/1 | - | **PX** | 1600/800 | 8/4 | 25 on 1600/1 Tap; 50 on 800/1 Tap |
| | 3 | METERING | 1600-800/1 | 20 | 0.2S | - | - | - |
| | 4 | TRANS. BACK UP . | 1600-800/1 | - | **PX** | 1600/800 | 8/4 | 25 on 1600/1 Tap; 50 on 800/1 Tap |
| | 5 | TRANS. DIFF | 1600-800/1 | - | **PX** | 1600/800 | 8/4 | 25 on 1600/1 Tap; 50 on 800/1 Tap |

Note:

1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869.
3. It is intended to use different ratios of the same CT at the same time for various protections and metering cores. The CTS should therefore be suitable for the above purpose by secondary tapings only. The ratio change by secondary taps is acceptable as long as the required CT specifications are achieved at all ratios.
4. The knee point voltage specified above shall be at higher ratio/ taps.
5. CT sizing calculations shall be submitted. Burden values and knee point voltage, shall be decided as per the calculations during detailed engineering.

**REQUIREMENTS FOR 145 KV CURRENT TRANSFORMER**

| No. of Cores | Core No. | Appli-cation | Current ratio | Output burden (VA) | Accuracy class | Min. knee pt. volt-age Vk | Max. CT sec. wdg. resist-ance(ohms) | Max. Excit-ation cur-rent at Vk (in mA) |
|---|---|---|---|---|---|---|---|---|
| 5 | 1 | BUS DIFF CHECK | 1600-1200/1 | - | PX | 1600-1200/1 | 8/4 | 25 on 1600/1 Tap; 50 on 1200/1 Tap |
| | 2 | BUS DIFF MAIN | 1600-1200/1 | - | PX | 1600-1200/1 | 8/4 | 25 on 1600/1 Tap; 50 on 1200/1 Tap |
| | 3 | METERING | 1600-1200/1 | 20 | **0.2S** | - | - | - |
| | 4 | TRANS. BACK UP | 1600-1200/1 | - | PX | 1600-1200/1 | 8/4 | 25 on 1600/1 Tap; 50 on 1200/1 Tap |
| | 5 | TRANS. DIFF | 1600-1200/1 | - | PX | 1600-1200/1 | 8/4 | 25 on 1600/1 Tap; 50 on 1200/1 Tap |

Note:

1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869.
3. It is intended to use different ratios of the same CT at the same time for various protections and metering cores. The CTS should therefore be suitable for the above purpose by secondary tapings only. The ratio change by secondary taps is acceptable as long as the required CT specifications are achieved at all ratios.
4. The knee point voltage specified above shall be at higher ratio/ taps.
5. CT sizing calculations shall be submitted. Burden values and knee point voltage, shall be decided as per the calculations during detailed engineering.

## MAJOR TECHNICAL PARAMETERS FOR CT

| Sl. No. | Description | 220kV system | 132 kV system |
|---|---|---|---|
| 1 | Rated voltage, Um (kVrms) | 245 | 145 |
| 2 | Rated frequency (Hz) | 50 | 50 |
| 3 | No. of Poles | 1 | 1 |
| 4 | Design ambient temperature (°C) | 50 | 50 |
| 5 | Rated Primary Current (A) | 1600 | 800/600 |
| 6 | Rated extended primary current | 150% | 150% |
| 7 | Rated short time thermal withstand current | 50kA for 3 sec | 40kA for 3 sec |
| 8 | Rated dynamic current | 125kAp | 100kAp |
| 9 | Temperature rise over design ambient temperature | As per IEC | |
| 10 | Rated Insulation levels | | |
| a) | Full wave impulse withstand voltage (1.2/50 microsecond) | | |
| i) | between line terminals and ground(kVpeak) | ±1050 | ±650 |
| b) | Switching impulse withstand voltage (250/2500 microsecond) (dry and wet) | | |
| i) | between line terminals and ground(kVpeak) | -NA- | -NA- |
| c) | One minute power frequency dry withstand voltage (dry and wet) | | |
| i) | between line terminals and ground(kVrms) | 460 | 275 |
| d) | One minute power frequency withstand voltage between secondary terminals& earth (kVrms) | 5kV | |
| 11 | Max. radio interference voltage for frequency between0.5 MHz and 2 MHz at (microvolts) | 1000 at 156kV rms | 500 at 92kV rms |
| 12 | Minimum Corona extinction voltage (kVrms) | -NA- | -NA- |

| | | | |
|---|---|---|---|
| 13 | Seismic acceleration (Horizontal) | 0.3g | 0.3g |
| 14 | Partial Discharge | As per IEC | As per IEC |
| 15 | Number of terminals | All terminals of control circuits are to be wired up to marshaling boxplus 20% spare terminals evenly distributed on all TBs. | |
| 16 | Minimum Creepage distance (mm) (31mm/kV) | 7565 | 4495 |
| 17 | System neutral earthing | Effectively Earthed | |

**Annexure-I: Actions required in case of defects observed during warranty period**

| Equipment | Nature of problem | Corrective measures to be taken by contractor |
|---|---|---|
| CT<br>(Oil filled) | **DGA Violation**<br>H2 > 300 ppm<br>C2H2> 2 ppm | CT to be **refurbished** or replaced |
| CT<br>(Oil filled) | **Violation of Tan delta**<br>Tan Delta:<br>>0.5%( during pre-commisioning )<br>>0.7% ( in operation)<br>or change w.r.t. to previous **year** value > 0.1% | Replacement of CT |
| CT & CVT | - Oil leakage<br>- Low Oil level<br>-Sec winding problem leading to open/ short circuit, saturation etc | Replacement or repair as per repairprocedure approved by QA. |
| CVT | Secondary voltage drift: Upto ± 0.5 volts Healthy<br>a) ± 0.5 **or beyond** | a) CVT to be replaced |

***Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.**

# 3.20 TECHNICAL SPECIFICATION ACSR CONDUCTORS AND ACCESSORIES FOR CONDUCTORS

### 3.20.1.0 SCOPE

3.20.1.1 This Section of the Specification covers the technical parameters for design, manufacture, testing at manufacturer's works and supply of Conductor, and accessories for Power Conductors.

### 3.20.2.0 POWER CONDUCTOR

### 3.20.2.1 TYPE OF CONDUCTOR

The ACSR Conductor shall generally conform to IEC: 61089/ IS: 398 (relevant part)/ ASTM:B-232 except where otherwise specified herein.

Conductor conforming to a standard other than the Indian Standard specification then an English version of the Standard in addition to the original standard if written in a language other than English should be submitted indicating clearly the advantage, if any, that would be obtained by the Employer for adopting this standard instead of the said India Standard.

### 3.20.2.2 STANDARD TECHNICAL PARTICULARS

All ACSR Conductor shall satisfy all the parameters as furnished in Technical Data Sheet.

All the aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding.

The steel strands shall be hot dip galvanised and shall have a minimum zinc coating.

### 3.20.2.3 MATERIAL

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity and copper content as per the values indicated in the STP. They shall have the same properties and characteristics as prescribed in IEC: 60889.

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP.

The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC: 60888.

The zinc used for galvanizing shall be electrolytic High-Grade Zinc of purity. It shall conform to and satisfy all the requirements of IS:209.

### 3.20.2.4 JOINTS IN WIRE

In the Aluminium wires no joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.

Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand as per STP.

In the Steel wires there shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

### 3.20.2.5 STRANDING

The wires used in construction of a ACSR conductor shall, before and after stranding, satisfy all requirements of IS 398 with latest amendments thereof.

The lay ratio of the different layers shall be within the limits as per the said Standard. In all constructions, the successive layers shall have opposite directions of lay, the outer most layer being right-handed. The wires in each layer shall be evenly and closely stranded. In aluminium alloy stranded conductors having multiple layers of wires, the lay ratio of any layer shall not be greater than the lay ratio of the layer immediately beneath it.

### 3.20.2.6 TYPE/ROUTINE/ACCEPTANCE TESTS

**Type Test:**

The following tests shall be conducted on a sample/sample of the conductor(s) required under the package from each stranding machine from which the conductor is to be manufactured & supplied:

a) DC resistance test on stranded conductor
b) UTS test on stranded conductor
c) Corona extinction voltage test (dry)
d) Radio interference voltage test (dry)

**Acceptance Test:**

a) Visual and dimensional check on drum
b) Visual check for joints, scratches etc. and length measurement of conductor by rewinding
c) Measurement of diameters of individual Steel and Aluminium strands
d) Galvanizing test on steel strands
e) Check for lay Ratios of various layers
f) Torsion and Elongation tests on steel strands
g) Breaking load test on steel and Aluminium strands
h) Wrap test on Steel & Aluminium strands
i) DC resistance test on Aluminium strands
j) Procedure qualification test on welded joint of Aluminium strands
k) Drum strength test (steel drum)
l) Barrel Batten strength test (wooden drum)

The above acceptance tests shall be repeated on one conductor sample taken from site in presence of AEGCL's representative for each 500km progressive supply. The tests shall be carried out by the supplier at his cost at its own premises or any other tests centre having required facilities. The sample shall be selected by AEGCL's site representative and the tests shall be witnessed by AEGCL's representative.

**Routine Tests:**

a) Check to ensure that the joints are as per Specification
b) Check that there are no cuts, fins etc. on the strands
c) Check that drums are as per Specification
d) All acceptance test as mentioned above to be carried out on aluminium and steel strands of 20% of drums

**Tests During manufacture:**

a) Chemical Analysis of Zinc used for galvanising
b) Chemical Analysis of Aluminium used for making Aluminium Strands
c) Chemical Analysis of Steel used for making Steel Strands.

### 3.20.2.7 REJECTION AND RETESTS

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

### 3.20.2.8 PACKING

All conductor reels shall conform to latest edition of IS: 1778 and be of dimensions approved by the Employer and made of seasoned wood sufficiently strong to ensure arrival at site, intact withstanding normal handling and hazards inland and ocean transit. The reels shall be of such size as to provide at least 12.5 mm clearance at all points from the conductor to the inner surface of the laggings.

All reels shall have two coats of aluminium paint on both inside and outside surface and shall be fitted with malleable iron Hub-bushings.

All reels shall be a layer of waterproof paper around the hub under the cable and another layer over the outermost layer of the cable, that is next to the lagging.

The reels shall be properly reinforced with galvanized steel wires or iron straps over the lagging in two places in an approved manner.

The wooden drums shall preferably be given protective coating of a reliable organic wood preservative before painting with Aluminium paint and the laggings shall also be given a similar treatment before being fixed on the drum. There shall be one standard length of Conductor in each drum.

### 3.20.2.9 TECHINCAL DATA SHEET FOR CONDUCTOR

**ACSR MOOSE**

| Sl. No | DESCRIPTION | PARTICULARS |
|---|---|---|
| I | II | III |
| 1 | Type of Conductor | Aluminium Conductor Steel Reinforced (ACSR) |
| 2 | No of Strand x size | 54 x 3.53 mm |
| 3 | Conductor over all diameter | 31.77 mm |
| 4 | Total sectional area | 597 $mm^2$ |
| 5 | Approx. weight | 2004 kg/km |
| 6 | Minimum UTS | 161.2 kN |
| 7 | Modulus of Elasticity (Final) | 0.7034 $kg/cm^2$ |
| 8 | Coefficient of linear expansion | 19.3 x $10^{-6}$ /$^0$C |
| 9 | Calculated maximum resistance/Km of Conductor at 20°C | 0.05552 ohms/km |
| 10 | Layer and No of Wire | |
| | Steel core | 1 |
| | 1st steel layer | 6 |
| | 1st Aluminium layer | 12 |
| | 2nd Aluminium layer | 18 |
| | 3rd Aluminium layer | 24 |
| 11 | **Aluminium strands after stranding** | |
| (a) | Diameter | |
| | Nominal | 3.53 |
| | Maximum | 3.55 |
| | Minimum | 3.51 |
| (b) | Minimum breaking load of strand | |
| | Before stranding | 1.57 |
| | After stranding | 1.49 |
| 12 | **Steel strand after stranding** | |
| (a) | Diameter | |
| | Nominal | 3.53 |
| | Maximum | 3.59 |
| | Minimum | 3.47 |
| (b) | Minimum breaking load of strand | |
| | Before stranding | 12.86 |
| | After stranding | 12.22 |
| 13 | DC resistance of the conductor at 20°C | 0.05552 |
| 14 | Direction of lay of outer layer | Right Hand |
| 15 | Linear mass of the conductor | |
| | Standard | 2004 |
| | Minimum | 1969 |
| | Maximum | 2040 |
| | | |

**ACSR Zebra**

| | | |
|---|---|---|
| 1. | Code Name | ZEBRA |

| | | |
|---|---|---|
| 2. | Equivalent area of Aluminium (sq.mm.) | 418.6 |
| 3. | Wire Strand (Al./Steel) | 54/7 |
| 4. | Nominal diameter of strand (Al./Steel) (mm.) | 3.18/3.18 |
| 5. | Weight (Kg/Km) | 1621 |
| 6. | Co-eff. of linear expansion per $^{o}C$ | $19.30x10^{-6}$ |
| 7. | Ultimate Tensile Strength (kgf.) | 13316 |
| 8. | Maxm. DC resistance at 20°C (/Km) (Calculated from maxm. Value of resistivity and min. Cross-sectional area) | 0.0680 |
| 9. | Zinc coating of steel: | |
| | i) No. of one minute dip | 3 |
| | ii) Min. wt. of zinc. ($gm.m^2$) | 260 |
| | iii) Purity of zinc (%) | 99.95 |
| 10. | Diameter of conductor (mm) | 28.62 |
| 11. | Standard Length (meter) | 1100 |

**ACSR Panther**

| Sl. No. | DESCRIPTION | ACSR 'PANTHER' |
|---|---|---|
| 1 | Code name | PANTHER |
| 2 | Number of strands & size | Al: 30/ 3.00 mm<br>St: 7/ 3.00 mm |
| 3 | Overall diameter | 21.00 mm |
| 4 | Breaking load | 130.32 kN |
| 5 | Weight of conductor | 974 kg / km |
| 6 | Co-efficient of linear expansion | $19.35x10^{-6}/^{0}C$ |
| 7 | Number of strands | |
| | Steel centre | 1 |
| | 1st Steel Layer | 6 |
| | 1st Aluminium Layer | 12 |
| | 2nd Aluminium Layer | 18 |
| | 3rd Aluminium Layer | - |
| 8 | Sectional area of Aluminium | $212.10\ mm^2$ |
| 9 | Total sectional area | $261.50\ mm^2$ |
| 10 | Calculated d.c. resistance at $20^0$ C | 0.1400 ohm/km |
| 11 | Ultimate tensile strength | 89.67 |

# 3.21 TECHNICAL SPECIFICATION FOR SURGE ARRESTERS

**3.21.1 SCOPE**

**3.21.1.1** This Section covers the specifications for design, manufacture, shop & laboratory testing before dispatch of 220kV, 132 kV and 33 kV 10 kA, Station class heavy duty, gapless metal (zinc) oxide Surge Arresters complete with fittings & accessories.

**3.21.2 STANDARDS**

**3.21.2.1** The design, manufacture and performance of Surge Arresters shall comply with IS: 3070 Part-3 unless otherwise specifically specified in this Specification

**3.21.3 GENERAL REQUIREMENT**

**3.21.3.1** The surge arrester shall draw negligible current at operating voltage and at the same time offer least resistance during the flow of surge current.

**3.21.3.2** The surge arrester shall consist of non-linear resistor elements placed in series and housed in electrical grade porcelain housing/silicon polymeric of specified creepage distance.

**3.21.3.3** The assembly shall be hermetically sealed with suitable rubber gaskets with effective sealing system arrangement to prevent ingress of moisture.

**3.21.3.4** The surge arrester shall be provided with line and earth terminals of suitable size. The ground side terminal of surge arrester shall be connected with 25x6 mm galvanized strip, one end connected to the surge arrester and second end to a separate ground electrode. The bidder shall also recommend the procedure which shall be followed in providing the earthing/system to the Surge Arrester.

**3.21.3.5** The surge arrester shall not operate under power frequency and temporary over voltage conditions but under surge conditions, the surge arrester shall change over to the conducting mode.

**3.21.3.6** The surge arrester shall be suitable for circuit breaker performing 0-0.3sec.-CO-3min-CO- duty in the system.

**3.21.3.7** Surge arresters shall have a suitable pressure relief system to avoid damage to the porcelain/ silicon polymeric housing and providing path for flow of rated fault currents in the event of arrester failure.

**3.21.3.8** The reference current of the arrester shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

**3.21.3.9** The Surge Arrester shall be thermally stable and the bidder shall furnish a copy of thermal stability test with the bid.

**3.21.3.10** The arrester shall be capable of handling terminal energy for high surges, external pollution and transient over voltage and have low losses at operating voltages.

**3.21.4 ARRESTER HOUSING**

**3.21.4.1** The arrester housing shall be made up of **polymer** and shall be homogenous, free from laminations, cavities and other flaws of imperfections that might affect the mechanical and dielectric quality. The housing shall be of uniform brown colour, free from blisters, burrs and other similar defects.

**3.21.4.2** Arresters shall be complete with insulating bases, fasteners for stacking units together, surge counters with leakage current meters and terminal connectors.

**3.21.4.3** The **housing shall be so coordinated that external flashover shall not occur due to application of** any impulse or switching surge voltage up to the maximum design value for arrester. The arresters shall not fail

due to contamination. The arrester housings shall be designed for pressure relief class as given in Technical Parameters of the specification.

**3.21.4.4** Sealed housings shall exhibit no measurable leakage.

**3.21.5 FITTINGS & ACCESSORIES**

**3.21.5.1** The surge arrester shall be complete with insulating bases, fasteners for stacking units together, surge counters with leakage current meters and terminal connectors.

**3.21.5.2** The terminals shall be non-magnetic, corrosion proof, robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The top metal cap and base of surge arrester shall be galvanized. The line terminal shall have a built-in clamping device which can be adjusted for both horizontal and vertical takeoff.

**3.21.5.3** Grading corona control rings, if necessary, shall be provided on each complete arrester pole for proper stress distribution.

**3.21.6 SURGE MONITOR**

**3.21.6.1** A self-contained discharge counter suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit. Leakage current meter with suitable scale range to measure leakage current of surge arrester shall also be supplied within the same enclosure. The number of operations performed by the arrester shall be recorded by a suitable cyclometric counter and surge monitor shall be provided with an inspection window. There shall be a provision for putting ammeter to record the current/alarm contacts in the control room if the leakage current exceeds the permitted value. Similar provision shall be considered for surge counter also.

**3.21.6.2** Surge monitor shall be mounted on the support structure at a suitable height so that the reading can be taken from ground level through the inspection window and length of connecting leads up to grounding point and bends are minimum.

**3.21.6.3** The surge counter shall be provided with a potential free contact rated for 220/110 Volt (DC) which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to Substation Automation System/RTU.

**3.21.7 TESTS**

**3.21.7.1 Test on Surge Arresters**

The Surge Arresters offered shall be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 3070 (Part-3). In addition, the suitability of the Surge Arresters shall also be established for the following:

i. Residual voltage test
ii. Reference voltage test
iii. Leakage current at M.C.O.V
iv. P.D. test
v. Sealing test
vi. Thermal stability test
vii. Aging and Energy capability test
viii. Watt loss test
ix. Each metal oxide block shall be tested for guaranteed specific energy capability in addition to routine/acceptance test as per IEC/IS.
x. The surge arrester housing shall also be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 2071.

**3.21.7.2 Galvanization Test**

All Ferrous parts exposed to atmospheric condition shall have passed the type tests and be subjected to routine and acceptance tests in accordance with IS: 2633 & IS 6745.

### 3.21.8 NAME PLATE

**3.21.8.1** The name plate attached to the arrester shall carry the following information:

i. Rated Voltage
ii. Continuous Operation Voltage
iii. Normal discharge current
iv. Pressure relief rated current
v. Manufacturers Trade Mark
vi. Name of Sub-station
vii. Year of Manufacturer
viii. Name of the manufacture
ix. Purchase Order Number along with date

### 3.21.9 PRE-COMMISSIONING TESTS

**3.21.9.1** Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval**.**

(a) Operation check of LA counters.
(b) Insulation resistance measurement.
(c) Capacitance and Tan delta measurement of individual stacks.
(d) Third harmonic resistive current measurement (to be conducted after energisation.)

### 3.21.10 TECHNICAL DATA SHEET FOR SURGE ARRESTER

| | **Particulars** | **Voltage class** | | |
|---|---|---|---|---|
| | | **220kV** | **132kV** | **33 kV** |
| | Rated voltage of arrester, kV | 198 | 120 | 30 |
| | Rated frequency, Hz | 50 Hz | 50 Hz | 50 Hz |
| | Nominal discharge current of arrester, kA | 10 | 10 | 10 |
| | Maximum residual voltage at nominal discharge current, kV (peak) | 650 | 395 | 108 |
| | Maximum steep current impulse residual voltage at kV (kVP) | 730 | 440 | 120 |
| | One minute power frequency withstand voltage of arrester insulation, kV (rms) | 460 | 275 | 70 |
| | 1.2 / 50 □ second impulse withstand voltage of arrester insulation, kV (peak) | 1050 | 650 | 170 |
| | Line discharge class | 3 | 3 | 2 |
| | **Insulator Housing** | | | |
| | Power frequency withstand test voltage(wet) (kV rms) | 460 | 275 | 70 |
| | Lightning impulse withstand tests voltage(KVp) | 1050 | 650 | 170 |
| | Pressure Relief Class | 40 | 40 | 40 |
| | Creepage distance not less than (mm) | 6125 | 3625 | 900 |

# 3.22 TECHNICAL SPECIFICATION FOR ISOLATORS

## 3.22.1 SCOPE

**3.22.1.1** This section of the specification is intended to cover design specifications for manufacture and testing of 220kV/132kV and 33 kV gang operated Isolators with all fittings and accessories.

**3.22.1.2** The Isolators are for outdoor installation suitable for horizontally mounting on mounting structures and for use at sub-stations.

**3.22.1.3** Isolators shall be supplied with Earth Switch as and where specified.

**3.22.1.4** The bidder shall offer ac motor operated Isolators and earth switches.

## 3.22.2 GENERAL

**3.22.2.1** The Isolators and accessories shall conform in general to IS 9921 (or IEC: 62271-102) except to the extent explicitly modified in specification.

**3.22.2.2** All isolating switches and earthing switches shall have rotating blades and pressure releasing contacts. All isolating and earth switches shall operate through 90° angle from closed position to fully open position.

**3.22.2.3** Complete isolator with all the necessary items for successful operation shall be supplied including but not limited to the following:

(i). Isolator assembled with complete base frame, linkages, operating mechanism, control cabinet, interlocks etc.

(ii). All necessary parts to provide a complete and operable isolator installation, control parts and other devices whether specifically called for herein or not.

(iii) The isolator shall be designed for use in the geographic and meteorological conditions as given in Section 1.

## 3.22.3 DUTY REQUIREMENTS

**3.22.3.1** Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.

**3.22.3.2** The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical and mechanical interlocks provided in the operating mechanism.

**3.22.3.3** In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of failsafe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated elsewhere in this specification.

**3.22.3.4** The earthing switches shall be capable of discharging trapped charges of the associated lines.

**3.22.3.5** The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation.

**3.22.3.6** The isolator shall be capable of making/breaking magnetizing current of 0.7A at 0.15 power factor and capacitive current of 0.7A at 0.15 power factor at rated voltage.

**3.22.4 CONSTRUCTIONAL DETAILS**

**3.22.4.1** All isolating switches and earthing switches shall have rotating blades and pressure releasing contacts. All isolating and earth switches shall operate through 90º angle from closed position to fully open position.

**3.22.5 Contacts:**

**3.22.5.1** The contacts shall be self-aligning and self-cleaning and so designed that binding cannot occur after remaining closed for prolonged periods of time in a heavily polluted atmosphere.

**3.22.5.2** No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

**3.22.5.3** Contact springs shall not carry any current and shall not lose their characteristics due to heating effects.

**3.22.5.4** The moving contact of double break isolator shall have turn-and -twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

**3.22.6 Blades:**

**3.22.6.1** All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts, shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. All ferrous castings except current carrying parts shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

**3.22.6.2** The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable adequate corona shield shall be provided. Corona shields/rings etc., shall be made up of aluminium/aluminium alloy.

**3.22.6.3** Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

**3.22.6.4** The switch shall be designed such that no lubrication of any part is required except at very infrequent intervals i.e., after every 1000 operations or after 5 years whichever is earlier.

**3.22.7 Insulators:**

**3.22.7.1** The insulator shall conform to IS: 2544 and/or IEC-60168. The insulators shall have a minimum cantilever strength of 600/400 Kgs. for 145/33 kV insulators respectively.

**3.22.7.2** Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

**3.22.8 Base:**

Each isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a supporting structure.

**3.22.9 EARTHING SWITCHES**

**3.22.9.1** Where earthing switches are specified, these shall include the complete operating mechanism and auxiliary contacts.

**3.22.9.2** The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

**3.22.9.3** The earthing switches shall be constructionally interlocked with the isolator so that the earthing switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks.

**3.22.9.4** Suitable mechanical arrangement shall be provided for de-linking electrical drive for mechanical operation.

**3.22.9.5** Each earth switch shall be provided with flexible copper/aluminium braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

**3.22.9.6** The frame of each isolator and earthing switches shall be provided with two reliable earth terminals for connection to the earth mat.

**3.22.9.7** Isolator design shall be such as to permit addition of earth switches at a future date. It should be possible to interchange position of earth switch to either side.

**3.22.9.8** The earth switch should be able to carry the same fault current as the main blades of the Isolators and shall withstand dynamic stresses.

**3.22.10 OPERATING MECHANISM**

**3.22.10.1** The bidder shall offer **motor operated** Isolators and earth switches. Earth Switches of 36 kV shall only be motor operated.

**3.22.10.2** Control cabinet/operating mechanism box shall be made of aluminium sheet of adequate thickness (minimum 3 mm).

**3.22.10.3** A "Local/Remote" selector switch and a set of open/ close push buttons shall be provided on the control cabinet of the isolator to permit its operation through local or remote push buttons.

**3.22.10.4** Provision shall be made in the control cabinet to disconnect power supply to prevent local/remote power operation.

**3.22.10.5** Suitable reduction gearing shall be provided between the motor and the drive shaft of the isolator. The mechanism shall stop immediately when motor supply is switched off. If necessary, a quick electromechanical brake shall be fitted on the higher speed shaft to effect rapid braking.

**3.22.10.6** Manual operation facility (with handle) should be provided with necessary interlock to disconnect motor.

**3.22.10.7** Gear should be of forged material suitably chosen to avoid bending/jamming on operation after a prolonged period of non-operation. Also, all gear and connected material should be so chosen/surface treated to avoid rusting.

**3.22.11 OPERATION**

**3.22.11.1** The main Isolator and earth switches shall be gang operated.

**3.22.11.2** The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments, by means of screw thread which can be locked with a lock nut after an adjustment has been made. The isolator and earth switches shall be provided with "over center" device in the operating mechanism to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

**3.22.11.3** Each isolator and earth switch shall be provided with a manual operating handle enabling one man to open or close the isolator with ease in one movement while standing at ground level. Detachable type manual operating handle shall be provided. Suitable provision shall be made inside the operating

mechanism box for parking the detached handles. The provision of manual operation shall be located at a height of 1000 mm from the base of isolator support structure.

**3.22.11.4** The isolator shall be provided with positive continuous control throughout the entire cycle of operation. The operating pipes and rods shall be sufficiently rigid to maintain positive control under the most adverse conditions and when operated in tension or compression for isolator closing. They shall also be capable of withstanding all torsional and bending stresses due to operation of the isolator. Wherever supported the operating rods shall be provided with bearings on either ends. The operating rods/ pipes shall be provided with suitable universal couplings to account for any angular misalignment.

**3.22.11.5** All rotating parts shall be provided with grease packed roller or ball bearings in sealed housings designed to prevent the ingress of moisture, dirt or other foreign matter. Bearings pressure shall be kept low to ensure long life and ease of operation. Locking pins wherever used shall be rustproof.

**3.22.11.6** Signaling of closed position shall not take place unless it is certain that the movable contacts, have reached a position in which rated normal current, peak withstand current and short time withstand current can be carried safely. Signaling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is at least 80% of the isolating distance.

**3.22.11.7** The position of movable contact system (main blades) of each of the Isolators and earthing switches shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the Isolators and earthing switch. The indicator shall be of metal and shall be visible from operating level.

**3.22.11.8** The Supplier shall furnish the following details along with quality norms, during detailed engineering stage.

(i) Current transfer arrangement from main blades of isolator along with milli volt drop immediately across transfer point.

(ii) Details to demonstrate smooth transfer of rotary motion from motor shaft to the insulator along with stoppers to prevent over travel.

### 3.22.12 TEST AND INSPECTION

**3.22.12.1** The switches shall be subjected to the following type test in accordance to with IS: 9920.

i. Dielectric test (impulse and one minute) power frequency withstands voltage.
ii. Temperature rise test
iii. Rated off load breaking current capacity
iv. Rated active load breaking capacity
v. Rated line charging breaking capacity
vi. Rated short time current
vii. Rated peak withstand current
viii. Mechanical and Electrical Endurance

**3.22.12.2** The equipment shall be subjected to the following routine test.

(i) Power frequency voltage dry test
(ii) Measurement of resistance of the main circuit
(iii) Operating test.

**3.22.12.3** The porcelain will have pull out test for embedded component and beam strength of porcelain base.

### 3.22.13 AUXILIARY SWITCHES

**3.22.13.1** All isolators and earth switches shall be provided with 220/110 volts, 6 Ampere auxiliary switches for their remote position indication on the control board and for electrical interlocking with other equipment. In addition to the auxiliary switches required for remote position indications and for their operation. There shall be six pairs of NO and six pairs of NC contacts for each isolating switch and three pairs of NO and three pairs of NC contacts for each earthing switch. All contacts shall be brought out to terminal blocks

### 3.22.14 CONNECTORS

**3.22.14.1** Each isolator shall be provided with appropriate number of bimetallic clamping type connectors as detailed in the schedule of requirement. The maximum length of jumper that may be safely connected or any special instruction considered necessary to avoid under loads on the post isolators should be stated by the bidder.

### 3.22.15 MOUNTING STRUCTURES

**3.22.15.1** All isolators and earthing switches shall be rigidly mounted in an upright position on their own supporting structures. Details of the supporting structures shall be furnished by the successful tenderer. The isolators should have requisite fixing details ready for mounting them on structures.

### 3.22.16 PRE-COMMISSIONING TESTS

Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

i. Insulation resistance of each pole.
ii. Manual and electrical operation and interlocks.
iii. Insulation resistance of control circuits and motors.
iv. Ground connections.
v. Contact resistance.
vi. Proper alignment so as to minimise to the extreme possible the vibration during operation.
vii. Measurement of operating Torque for isolator and Earth switch.
viii. Resistance of operating and interlocks coils.
ix. Functional check of the control schematic and electrical & mechanical interlocks.
x. 50 operations test on isolator and earth switch.

### 3.22.17 TECHNICAL DATA SHEET FOR ISOLATORS

| No. | Technical Particulars | Isolators class | | |
|---|---|---|---|---|
| | | 220 kV | 132 kV | 33 kV |
| 1 | Nominal system voltage, kV | 220 | 132 | 33 |
| 2 | Highest system voltage, kV | 245 | 145 | 36 |
| 3 | Rated frequency, Hz. | 50 | 50 | 50 |
| 4. | Type of Isolator | Single Centre Break | Single Centre Break | Double Break, centre pole rotating |
| 5 | Rated continuous current, A | 3150 | 2000 | 1250 |
| 6 | Rated short time current, kA | 50 | 40 | 25 |
| 7 | Rated duration of short time current, (second) | 3 | 3 | 1 |
| 8 | Rated lightning impulse withstand voltage, kV (peak) | | | |
| | i) To earth & between poles | 1050 | 650 | 170 |
| | ii) Across isolating distance | 1220 | 750 | 195 |
| 9 | Rated 1 minute power frequency withstand voltage, kV (rms) | | | |
| | i) To earth & between poles | 315 | 275 | 70 |
| | ii) Across isolating distance | 530 | 460 | 80 |
| 10 | Minimum Creepage distance of insulators, mm | 7595 | 4495 | 900 |
| 11 | Temperature rise | As per relevant IEC 62271 -102/ IS 9921 | | |

# 3.23 TECHNICAL SPECIFICATION FOR POWER & CONTROL CABLES

### 3.23.1.0 GENERAL REQUIREMENT

3.23.1.1 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.

3.23.1.2 For all control/protection/instrumentation purposes PVC insulated armoured control cables of minimum 2.5 sq. mm Size with stranded Copper conductors shall be used.

3.23.1.3 While preparing cable schedules for control/protection purpose following shall be ensured:

i. Separate cables shall be used for AC & DC.

ii. For different cores of CT & PT separate cable shall be used.

iii. At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

3.23.1.4 For control cabling, including CT/VT circuits, 2.5 sq.mm size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration additional cores shall be used. Further, for potential circuits of energy meters separate connections by 2 cores of 2.5sq.mm size shall be provided.

3.23.1.5 Standard technical data sheets for cable sizes up to and including 1100V are enclosed at Clause 3.23.3. Cable sizes shall be offered /manufactured in accordance with parameters specified in standard technical data sheets. Technical data sheet for any other cores/sizes required during detailed engineering shall be separately offered for Employer's approval by the contractor/supplier.

### 3.23.2.0 TECHNICAL REQUIREMENTS

3.23.2.1 General

3.23.2.1.1 The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water.

3.23.2.1.2 The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.

3.23.2.1.3 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables, armours shall be of H4 grade Aluminium.

3.23.2.1.4 The fillers and inner sheath shall be of non-hygroscopic, fire-retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

3.23.2.1.5 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

3.23.2.1.6 Strip wire armouring method shall not be accepted for any of the cables. For control, cables only round wire armouring shall be used.

3.23.2.1.7 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

3.23.2.1.8 All the cables shall pass fire resistance test as per IS:1554 (Part-I)

3.23.2.1.9 The normal current rating of all PVC insulated cables shall be as per IS:3961.

3.23.2.1.10 Repaired cables shall not be accepted.

3.23.2.1.11 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

3.23.2.2 XLPE Power Cables

The XLPE (90°C) insulated cables shall be of FR type, C1 category conforming to IS: 7098 (Part-I) and its amendments read along with this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted. In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC of type ST-2 of IS: 5831. When armouring is specified for single core cables, the same shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC of Type ST-2 of IS: 5831 for all XLPE cables.

3.23.2.3 PVC Power Cables

3.23.2.3.1 The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part- I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multicore cables. For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS 5831 for all cables.

3.23.2.4 PVC Control Cables

3.23.2.4.1 The PVC (70°C) insulated control cables shall be of FR type C1 category conforming to IS: 1554 (Part- 1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour.

3.23.2.4.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS 1554 (Part-1).

### 3.23.3 DATA SHEET FOR CABLES

**1. Power Cables**

| Sl. No. | Description | 3 ½ C 300mm2 | Other Power Cables | |
|---|---|---|---|---|
| | | | 70 mm2, 35 mm2, 25mm2, 16 mm2 | 6 mm2& 4mm2 |
| 1 | Applicable Standard | IS: 7098/PT-I & its referred standards | IS: 1554/PT-I& its referred standards | |
| 2 | Type Designation | A2XWY | AYFY | AYWY |
| 3 | Rated Voltage(volts) | 1100 | 1100 | 1100 |
| 4 | Type & Category | FR & C1 | FR & C1 | FR & C1 |
| 5 | Suitable for earthed or unearthed system | Suitable for both | | |
| 6 | Conductor | | | |
| | a) Material | Stranded Aluminium as per IS : 8130 | | |
| | b) Grade | H 2 (Electrolytic grade) | | |
| | c) Number of wires(No.) | As per IS 8130 | | |
| | d) Form of Conductor | Stranded compacted circular/sector shaped | Stranded compacted circular/sector shaped | Non-compacted Stranded circular |
| | e) Direction of lay of stranded layers | Outermost layer shall be R.H lay & opposite in successive layers | | |
| 7 | Insulation | | | |
| | a) Composition of insulation | Extruded XLPE as per IS-7098 Part(1) | Extruded PVC type A as per IS-5831 | Extruded PVC type A as per IS-5831 |
| | b) Thickness of insulation(mm) | As per applicable Standard | | |
| 8 | Inner Sheath material | Extruded PVC type ST-2 as per IS-5831 | Extruded PVC type ST-1 as per IS- 5831 | |
| 9 | Type and material of armour | Gal. Steel wire | Gal. Steel Strip | Gal. Steel wire |
| 10 | Outer Sheath (PVC) | ST-1 & FR | ST-2 & FR | ST-2 & FR |
| 11 | Overall diameter of cable | As per applicable Standard | | |

**2. Control Cables**

| Sl. No. | Description | Particulars |
|---|---|---|
| 1 | Applicable Standard | IS: 1554/PT-I & its referred standards |
| 2 | Type Designation | YWY |
| 3 | Rated Voltage(volts) | 1100 |
| 4 | Type & Category | FR & C1 |
| 5 | Suitable for earthed or unearthed system | Suitable for both |
| 6 | Conductor | |
| | a) Material | Plain annealed High Conductivity stranded Copper (as per IS 8130) |
| | b) Grade | Electrolytic |
| | c) Number of wires(No.) | As per IS 8130 |
| | d) Form of Conductor | Non-compacted Stranded circular |
| | e) Direction of lay of stranded layers | Outermost layer shall be R.H lay |
| 7 | Insulation | |
| | a) Composition of insulation | Extruded PVC type A as per IS-5831 |
| | b) Thickness of insulation(mm) | As per applicable Standard |
| 8 | Inner Sheath material | Extruded PVC type ST-1 as per IS-5831 |
| 9 | Type and material of armour | Gal. Steel wire |
| 10 | Outer Sheath (PVC) | ST-1 & FR |
| 11 | Overall diameter of cable | As per applicable Standard |
| 12 | No. of Cores | As per Bill of Materials |

# 3.24 TECHNICAL SPECIFICATION FOR CONSTRUCTION WORKS IN SUBSTATIONS

**3.24.1.0 GENERAL**

3.24.1.1 The intent of this Section of the Specification is to cover requirements which are to be followed in construction of switchyards including civil works in the switchyard. Irrespective of whether mentioned or not all the equipment shall be supplied at site, erected, tested and commissioned. The prices quoted in the Price Schedule are deemed to include for these activities.

3.24.1.2 The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the Employer based on Drawings supplied to the Contractor by the Employer with this specification. For all structures, foundations, etc., necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance based on the input provided (drawings and design parameters) by the Employer in this Technical Specification. Certain minimum requirements are indicated in this Section for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

3.24.1.3 A set of drawings are enclosed for reference of the Bidder. The drawings shall be treated as for bidding purpose only.

3.24.1.4 The contractor shall maintain the overall dimensions of the substation, buildings, bay length, bay width, phase to earth clearance, phase to phase clearance, ground clearances, sectional clearances, clearances between buses and bus heights but may alter the spacing between equipment based on actual dimensions equipment offered to obtain the statutory electrical clearances required for the substation and to suite the physical requirements of available land for the substation etc.

3.24.1.5 The enclosed drawings give the basic scheme, layout of substation, associated services etc. in case of any discrepancy between the drawings and text of specification, the requirements of text shall prevail in general. However, the Contractor is advised to get these clarified from Employer.

**3.24.2.0 Surface Preparation and Stone Spreading**

3.24.2.1 The switchyard works of the above substations under the scope of this bid shall be carried out in the existing vacant bays with earthing system already in place. It is responsibility of the Contractor to earth all the newly erected equipment and structures by connecting to the existing earth mat. It is also in the scope of Contractor to clean, level and spreading of gravels after installation of new equipment and structures in these bays.

3.24.2.2 A surface course of minimum 100 mm thickness of 20 mm nominal size river pebbles or (single size ungraded) broken stone shall be spread.

**3.24.3.0 Transformer Foundation and Oil Recovery System**

3.24.3.1 The Contractor shall provide an oil recovery system for all power transformers containing insulating oil, integrated with the transformer foundations.

3.24.3.2 The oil recovery system shall be provided in order to avoid spread of fire by the oil, and for environmental protection.

Each transformer including oil conservator tank and cooler banks, etc., shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall from the transformer shall be 20% of the transformer height or 0.8 m whichever is more. The oil collection pit thus formed shall have a void volume equal to 125% volume of total oil in the transformer.

The grating shall be made of Galvanised MS flat of size 40 mm x 5 mm placed at 30 mm center to center and 25 mm x 5 mm GI MS flat at a spacing of 150 mm at right angle to each other. Maximum length of grating shall be 2000 mm and width shall not be more than 500 mm. The gratings, supported on Galvanised ISMB 150 mm, shall be placed at

the formation level and will be covered with 100 mm thick layer of broken/crushed/non-crushed stone having size 35 mm to 45 mm.

Each oil collection pit shall be drained towards a sump pit within the collection whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry and clean.

3.24.3.3 The retaining walls which make up the oil collection pit shall be made of fire-resistant material such as reinforced cement concrete, fire brick etc., and shall be impervious to oil.

The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside.

The bottom of the pit shall have a uniform slope towards the sump pit.

3.24.3.4 Drainage
A device showing level of sump pit shall be provided by Contractor, fitted along with the automatic/manual pumping system, which shall have sufficient capacity to evacuate the rainwater from the sump pit. The Contractor may propose another better scheme, if agreed by Employer.

If the heights of the retaining walls, which form the oil collection pit, exceed 60 cm, steps shall be provided to facilitate access to the oil collection pit.

When designing the oil collection pit, the movement of the transformer must be taken into account.

3.24.3.5 Transformers shall be mounted on a rail fitted on top of the foundation for its easy removal from foundation/oil collection pit.

**3.24.4.0 Cable Trenches and Cable Trays**
3.24.4.1 Design and construction of cable trenches with pre-cast removal R.C.C cover (with lifting arrangement) as per drawing enclosed with the Bid Documents shall be carried out by the Contractor.

3.24.4.2 Cable Trays
(i). The cable trays shall be of G.S. sheet and minimum thickness of sheet shall be 2mm.
(ii). Finished Cable Trays shall have a standard width of 300 mm.
(iii). The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards. Contractor shall have to demonstrate all tests as per specification and equipment shall comply with all requirements of the specification.

a) Test for galvanising (Acceptance Test)
The test shall be done as per approved standards.

b) Deflection Test: (Type Test)
A 2.5 metre straight section of 300mm, wide cable tray shall be simply supported at two ends. A uniform distributed load of 76 kg/m shall be applied along the length of the tray. The maximum deflection at the mid-span shall not exceed 7mm.

3.24.4.3 The Contractor shall provide embedded steel plates of adequate size on the walls of concrete cable trench for supports for cable trays. Insert plates will be provided at an interval of 2000 mm.

3.24.4.4 The cable trench walls shall be designed for following loads: -
(a) Dead load of 155 kg/M length of cable support (tray) + 75 kg on one tier at the end.
(b) Triangular earth pressure + uniform surcharge pressure of 2T/m2.

3.24.4.5 RCC cable trench cover shall be designed for self-weight of slab + UDL of 2000 kg/m2 + a concentrated load of 200 kg at center of span on each slab panel.

3.24.4.6 Cable trench inside the Control Room shall be covered with 6 mm thick chequered plates with lifting arrangement.

3.24.4.7 Cable trench crossing the road/rails shall be designed for class AA. Loading of IRC/relevant IS Code and should be checked for transformer loading.

3.24.4.8 Trenches shall be drained. Necessary sumps be constructed and sump pumps, if necessary, shall be supplied. Cable trenches shall not be used as storm water drains.

3.24.4.9 The top of trenches shall be kept at least 100 mm above the finished ground level. The top of cable trench shall be such that the surface rainwater does not enter the trench.

3.24.4.10 All metal parts inside the trench shall be connected to the earthing system.

3.24.4.11 Cables from trench to equipment shall run in hard conduit pipes.

3.24.4.12 Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.

3.24.4.13 The trench bed shall have a slope of 1/500 along the run and 1/250 perpendicular to the run.

3.24.4.14 All the construction joints of cable trenches i.e., between base slab to base slab and the junction of vertical wall to base slab as well as from vertical wall to wall and all the expansion joints shall be provided with approved quality PVC water stops of approx. 230 x 5 mm size for those sections where the ground water table is expected to rise above the junction of base slab and vertical wall of cable trenches.

3.24.4.15 Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12 mm thick 1:6 cement sand mortar.

**3.24.5.0 Foundation and RCC Construction**

3.24.5.1 General

3.24.5.1.1. Work covered under this Clause of the Specification comprises the design and construction of foundations and other RCC constructions for switchyard structures, equipment supports, trenches, drains, jacking pad, control cubicles, bus supports, transformer, marshalling kiosks, auxiliary equipment and systems, buildings, tanks, boundary wall or for any other equipment or service and any other foundation required to complete the work.

3.24.5.1.2. Concrete shall conform to the requirements mentioned in IS: 456 and all the tests shall be conducted as per relevant Indian Standard Codes as mentioned in Standard field quality plan appended with the specification.

A minimum grade of M15 concrete (1:2:4 mix) shall be used for all structural/load bearing members as per latest IS 456.

3.24.5.1.3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.

3.24.5.1.4. The switchyard foundation's plinths and building plinths shall be minimum 300 mm and 500 mm above finished ground level respectively.

3.24.5.1.5. Minimum 75 mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches, etc., to provide a base for construction.

3.24.5.1.6. Concrete made with Portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.

3.24.5.1.7. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof.

The Spread footings foundation or pile foundation as may be required based on soil/subsoil conditions and superimposed loads shall be provided.

3.24.5.1.8. If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre cast or under reamed type as per relevant parts of IS Code 2911. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests from the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

3.24.5.2 Design

3.24.5.2.1. All foundation shall be of reinforced cement concrete. The design and construction of RCC structures shall be carried out as per IS: 456 and minimum grade of concrete shall be M-15. Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the Employer.

3.24.5.2.2. Limit state method of design shall be adopted unless specified otherwise in the specification.

3.24.5.2.3. For detailing of reinforcement IS: 2502 and SP: 34 shall be followed. Cold twisted deformed bars (Fe-415 N/mm2) conforming to IS: 1786 shall be used as reinforcement. However, in specific areas, mild steel (Grade-I) conforming to IS: 432 can also be used. Two layers of reinforcement (on inner and outer face) shall be provided for wall and slab sections having thickness of 150 mm and above. Clear cover to reinforcement towards the earth face shall be minimum 40 mm.

3.24.5.2.4. RCC water retaining structures like storage tanks, etc., shall be designed as uncracked section in accordance with IS: 3370 (Part I to IV) by working stress method. However, water channels shall be designed as cracked section with limited steel stresses as per IS:3370 (Part I to IV) by working stress method.

3.24.5.2.5. The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and or superstructure and other conditions, which produces the maximum stresses in the foundation or the foundation component and as per the relevant IS Codes of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.

3.24.5.2.6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

3.24.5.2.7. Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/harmful to the concrete foundations.

3.24.5.2.8. RCC columns shall be provided with rigid connection at the base.

3.24.5.2.9. All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant IS Codes or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.

3.24.5.2.10. Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of sub-structures of any underground enclosures, earth pressure at rest shall be considered.

3.24.5.2.11. In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq.m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, sub-structure of any underground hollow enclosure, etc., for the vehicular traffic in the vicinity of the structure.

3.24.5.2.12. Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:
a) Full water pressure from inside and no earth pressure and ground water pressure and surcharge pressure from outside (application only to structures, which are liable to be filled up with water or any other liquid).
b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.

3.24.5.2.13. The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.

3.24.5.2.14. The foundations of transformer and circuit breaker shall be of block type foundation. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

3.24.5.2.15. The tower and equipment foundations shall be checked for a factor of safety of 2.0 for normal condition and 1.50 for short circuit condition against sliding, overturning and pullout. The same factors shall be used as partial safety factor overloads in limit state design also.

3.24.5.3 Admixtures & Additives
3.24.5.3.1 Only approved admixtures shall be used in the concrete for the Works. When more the one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.

3.24.5.3.2 Admixtures in concrete shall conform to IS: 9103. The water proofing cement additives shall conform to
IS: 2645. Employer shall approve concrete Admixtures/Additives.

3.24.5.3.3 The Contractor may propose and the Employer may approve the use of a water-reducing retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.

3.24.5.3.4 The water reducing set-retarding admixture shall be an approved brand of Ligno sulphonate type admixture.

3.24.5.3.5 The water proofing cement additives shall be used as required/advised by the Employer.

**3.24.6.0 Bus Bars and Bus Bar Supports**
3.24.6.1.1 The bus bars shall be outdoor strung bus bars with ACSR conductor supported on lattic.

3.24.6.1.2 If asked for, the substation steel structures shall be designed as per Section-3 of this specification.

**3.24.7.0 ACSR Conductors**
3.24.7.1 The Conductor shall conform to IS: 398 (latest edition) except where otherwise specified herein.

3.24.7.2 The details of the ACSR Moose, ACSR Zebra and ACSR Panther conductors are tabulated below:

| Sl. No. | DESCRIPTION | ACSR 'MOOSE' | ACSR 'ZEBRA' | ACSR 'PANTHER' |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | Code name | MOOSE | ZEBRA | PANTHER |
| 2 | Number of strands & size | Al: 54/ 3.53 mm<br>St: 7/ 3.53 mm | Al: 54/ 3.18 mm<br>St: 7/ 3.18 mm | Al: 30/ 3.00 mm<br>St: 7/ 3.00 mm |
| 3 | Overall diameter | 35.05 mm | 28.62 mm | 21.00 mm |
| 4 | Breaking load | 136.38 kN | 130.32 kN | 130.32 kN |
| 5 | Weight of conductor | 2004 Kg/km | 1621 kg/km | 974 kg/km |
| 6 | Co-efficient of linear expansion | $23x10^{-6}$ / ºC | $19.35x10^{-6}$ / ºC | $19.35x10^{-6}$ / ºC |
| 7 | Number of strands | | | |
| | Steel centre | 1 | 1 | 1 |
| | 1st Steel Layer | 6 | 6 | 6 |
| | 1st Aluminium Layer | 12 | 12 | 12 |
| | 2nd Aluminium Layer | 18 | 18 | 18 |
| | 3rd Aluminium Layer | 24 | 24 | - |
| 8 | Sectional area of Aluminium | 528.50 mm² | 428.90 mm² | 212.10 mm² |
| 9 | Total sectional area | 597.00 mm² | 484.50 mm² | 261.50 mm² |
| 10 | Calculated D.C. resistance at 20º C | 0.05552 ohm/km | 0.06869 ohm/km | 0.1400 ohm/km |
| 11 | Ultimate tensile strength | 161.2 kN | 130.32 kN | 89.67 |

**3.24.8.0 Electrical Clearances**

3.24.8.1 Following minimum electrical clearances (outdoor) shall be maintained in the switchyard:

| Sl. No. | Clearance | 220 KV | 132 kV | 33 KV |
|---|---|---|---|---|
| 1 | Phase to Phase | 2400 mm | 1300 mm | 320 mm |
| 2 | Phase to Earth | 2400 mm | 1300 mm | 320 mm |
| 3 | Sectional Clearance | 5000 mm | 4000 mm | 2800 mm |
| 4 | Live part to ground | 5500 mm | 4600 mm | 3700 mm |
| 5 | Base of insulator (supporting live part) to ground | 2500 mm | 2500 mm | 2500 mm |

**3.24.9.0 Earthing System**

3.24.9.1 The earthing system in the existing substations is consists of MS/GI flats laid in mesh at a depth of 0.75 meter to 1.0 meter with combination of electrodes. This existing earthing system shall be extended to the extended portion of the switch yard by laying GI flats of size 50x10 mm (or as specified in the Bill of Materials) covering the entire extended switchyard area and earth electrodes of cast iron pipes distributed all over the mesh. The earth electrodes shall also be placed all around the periphery of the mesh at regular intervals.

3.24.9.2 General

3.24.9.2.1 GI flats of size 25 mm X 6 mm shall be used for all risers.

3.24.9.2.2. The earth mat shall be created by laying the earthing conductor (GI MS flats) in both directions perpendicularly. The mesh points so created and all other joints shall be welded and painted and painted with rust proof paint after welding.

3.24.9.2.3. The extension of earth mat shall be made by laying the GI flats at a distance of 4.0 meter in both directions perpendicularly and at the same depth of existing earth mat. The mesh points so created and all other joints shall be welded and painted and painted with rust proof paint after welding.

3.24.9.2.4. The all-earth electrodes and risers for equipment and other earthing must be connected at mesh points of the earth mat. All such connections shall be welded.

3.24.9.2.5. All metallic supporting structures and non-current carrying metallic parts of all equipment shall be provided with double earthing.

3.24.9.2.6. All LAs, and all transformer neutrals must be earthed through separate earth electrodes and in turn these electrodes shall be connected to the main earth grid.

3.24.9.2.7. All metallic parts in cable trenches shall also be connected to the earth mat.

3.24.9.2.8. The extended switchyard area shall be covered with gravel or crushed rocks to a thickness of 150 mm. This covering should cover entire switchyard area and also extend beyond the periphery of the earth mat to an extent of at least 1 meter.

3.24.9.3 Summary of Earthing System

| Sl. No. | Item | Size | Materials |
|---|---|---|---|
| 1. | Main Earthing Conductor to be buried in ground | 50mm x 10 mm | GI Flat |
| 2. | Conductor above ground & earthing leads (for equipment) | 50mm x 10 mm | GI Flat |
| 3. | Conductor above ground & earthing leads (for columns & aux. structures) | 50mm x 10 mm | GI Flat |
| 4. | Earthing of indoor LT panels, Control panels and outdoor marshalling boxes, MOM boxes, Junction boxes & Lighting Panels etc. | 50mm x 10 mm | GI Flat |
| 5. | Rod Earth Electrode | 40mm dia, 3000 mm long | Mild Steel |
| 6. | Pipe Earth Electrode (in treated earth pit) as per IS 3043 | 40mm dia, 3000 mm long | Galvanised Steel |

**3.24.10.0 Protection Against Direct Lightning**

3.24.10.1 Protection against direct lightning shall be provided by stringing 7/3.66 mm G.I. wires conforming to IS 2141.

3.24.10.2 G.I. wires for shielding shall conforming to IS 2141.Parameters of galvanised steel wires shall be as follows:
a) No of Strand: 7
b) Diameter of single strand: 3.66 mm
c) Minimum Breaking Load: 6970 KG
d) Overall Diameter: 10.98 mm
e) Area: 72.25 mm2

**3.24.11.0 Bay Marshalling Kiosks**

3.24.11.1 One number of bay marshalling kiosk shall be provided for each 220 kV and 132 kV bay and one number kiosk shall be provided for each two numbers of 33 kV bays under present scope. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose: -
i) To receive two incoming 415V, 3 phase,63Amps, AC supply with auto changeover and MCB unit and distribute minimum four outgoing 415V, 3 phase, 16 Amps AC supplies controlled by MCB.

ii) To distribute minimum six outgoing 240V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.

**3.24.12.0 Insulator and Hardware Fittings**

3.24.12.1 General

a) The Contractor shall supply insulators of suspension, tension and post type as required complete with all necessary hardware and accessories, including fittings for fixing insulators to steel structures as required.

b) The porcelain shall be sound, free from defects, thoroughly vitrified and smoothly glazed.

c) Unless otherwise specified, the glaze shall be brown colour. The glaze shall cover all the porcelain parts of the insulators except those areas which serve as support during firing or are left unglazed for purpose of assembly.

d) The design of the insulator shall be such that stress due to expansion and contraction in any part of the insulator shall not lead to deterioration. The porcelain shall not engage directly with hard metal.

e) Cement use in the construction of insulator shall not cause fracture by expansion or loosening by contraction and proper care shall be taken to locate the individual parts correctly during cementing. The cement shall not give rise to chemical reaction with metal fitting and its thickness shall be as uniform as possible.

f) Pins and caps shall be made of drop forged steel, duly hot dip galvanized as per IS 2629.These shall not be made by jointing, welding, shrink fitting or any other process.

g) Security clips/split pins shall be made of good quality of stainless steel.

h) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings.

i) Post type insulators shall be of long rod type or solid core type and preferably of single piece type for all voltage classes. These shall be complete with necessary fittings to hold Aluminium tubes or ACSR conductor as required.

j) The items of hardware and fittings shall make complete assemblies which are necessary for their satisfactory performance. Such parts shall be deemed to be within the scope of this specification.

3.24.12.2 Disc Insulator Strings

Each insulator string shall consist of following numbers of Disc Insulator Units & parameters.

| Sl. No. | Type of string | No of Disc Insulator Unit for | | |
|---|---|---|---|---|
| | | 220 kV | 132 kV | 33 kV |
| 1 | Suspension | 14 | 9 | 3 |
| 2 | Tension | 15 | 10 | 4 |

3.24.12.3 Parameters

3.24.12.3.1 Disc Insulators

a) Type : Ball and Socket
b) Colour : Brown
c) Surface : Glazed
d) Locking Device : W or R type security clip
e) Size of Disc : 255 mm x 145 mm
f) Size of Pin Ball : 16 mm
g) Creepage Distance (Min) :320 mm
h) Electro mechanical Strength : 70 KN
i) Power frequency withstand test voltage : 75 KV Dry, 45 KV Wet
j) Minimum dry Impulse withstand : 125 KV peak Test voltage (+/- wave)
k) Puncture Voltage : 1.3 X actual dry flash over voltage.

3.24.12.3.2. Post Insulators

| Sl. No. | Parameters | 220 kV | 132 kV | 33 kV |
|---|---|---|---|---|
| 1 | Highest system voltage | 245 kV | 145 kV | 36 kV |
| 2 | Dry one minute power frequency test Voltage | 510 kV | 275 kV | 75 kV |
| 3 | Wet one minute power frequency test Voltage | 460 kV | 275 kV | 75 kV |
| 4 | Impulse voltage withstand test | 1050 kV | 650 kV | 170 kV |
| 5 | Minimum Creepage Distance | 6125 mm | 3625 mm | 900 mm |
| 6 | Minimum Bending Strength (upright) | 6 kN | 4 kN | 3 kN |

**3.24.13.0 Clamps, Connectors and Spacers**

3.24.13.1 Clamps and connectors shall conform to IS 2121 unless otherwise mentioned hereunder.

3.24.13.2 Clamps and connectors shall be made of materials listed below: -

(i) For connecting ACSR: Aluminium alloy casting conforming to designation A6 of IS 617.
(ii) For connecting equipment: Bimetallic connectors made from aluminium alloy terminals made of copper casting conforming to designation A 6 of IS 617.
(iii) For connecting GI Shield wire: Malleable iron casting.
(iv) Expansion Connectors: Copper lamination to grade FRTP-2 of IS 191.
(v) Bolts, nuts, plain washers: Hot dip galvanised mild steel and spring washers for items (i), (ii) and (iii).

3.24.13.3 Spacers

Spacers shall conform to IS 10162. Spacers for bundle conductors (where specified) shall be provided at but not limited to the following locations:

(i) At intervals not exceeding 2.5 meters in case of strung bus bars or other bundled strung conductors.
(ii) At one meter interval in case of jumper connections.

No magnetic material shall be used in fabrication of spacers except for the GI bolts and nuts.

3.24.13.4 T Clamp and Equipment Clamps

**a) T Clamps:**

i. Standard Specification and tests shall be as per IS:5561.
ii. For connecting ACSR conductor aluminium alloy casting conforming to designation A 6 of IS 617.
iii. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electrogalvanized.
iv. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.
v. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.
vi. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.
vii. No part of a clamp shall be less than 12 mm thick for fittings suitable up to size of ACSR Panther conductor, no part of a clamp shall be less than 15 mm thick for fittings suitable for ACSR Zebra conductor and ACSR Moose conductor.
viii. All sharp edges and corners shall be blurred and rounded off.
ix. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.
x. From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.

**b) Equipment Clamps (CB, ISOLATOR, CT and PI):**

i. Standard Specification and tests shall be as per IS:5561.
ii. For connecting ACSR conductor aluminium alloy casting conforming to designation A 6 of IS 617.
iii. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electrogalvanized.
iv. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.
v. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.
vi. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.
vii. No part of a clamp shall be less than 12 mm thick for fittings suitable up to size of ACSR Panther conductor, no part of a clamp shall be less than 15 mm thick for fittings suitable for ACSR Zebra conductor and ACSR Moose conductor.
viii. All sharp edges and corners shall be blurred and rounded off.
ix. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.
x. From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.

**3.24.14.0 Supply of Construction Materials by The Contractor**

3.24.14.1 The contractor has to make his own arrangements for procurement, supply and use of construction materials like cement, M.S. rounds, H.B.G. metal and sand.

3.24.14.2 Cement

The contractor has to make his own arrangements for the procurement of cement to required specifications required for the work subjected to the follows:

a) The contractor shall procure cement (approved BSI marked of OPC or PPC), required for the work sonly from reputed cement factories (Main producer) acceptable to the Engineer-in-Charge. The contractor shall be required to be furnished to the Engineer-in-Charge bills of payment and test certificates issued by the manufacturers to authenticate procurement of quality cement from the approved cement factory. The contractor shall make his own arrangement for adequate storage of cement.

b) The contractor shall procure cement in standard packing of all 50 kg per bag from the authorized manufacturers. The contractor shall make necessary arrangement at his own cost to the satisfaction of Engineer-in-Charge for actual weighment of random sample from the available stock and shall conform with the specification laid down by the Indian Standard Institution or other standard foreign institutions laid down by the Indian Standard Institution or other standard foreign institutions as the case may be. Cement shall be got tested for all the tests as directed by Engineer-in-Charge at least one month in advance before the use of cement bags brought and kept on site Stores. Cement bags required for testing shall be supplied by the contractor free of cost. If the tests prove unsatisfactory, then the charges for cement will be borne by the Contractor.

c) The Contractor should store the cement of 60 days requirement at least one month in advance to ensure the quality of cement so brought to site and shall not remove the same without the written permission of the engineer-in-Charge. The Contractor should store the cement of 60 days requirement at least one month in advance to ensure the quality of cement so brought to site and shall not remove the same without the written permission of the engineer-in-Charge. The Contractor shall forthwith remove from the works area any cement that the Engineer-in-Charge may disallow for use, an account of failure to meet with required quality and standard.

d) The contractor shall further, at all times satisfy the Engineer-in-Charge on demand, by production of records and books or by submission of returns and other proofs as directed, that the cement is being used as tested and approved by Engineer-in-Charge for the purpose and the Contractor shall at all times, keep his records up to date to enable the Engineer-in-Charge to apply such checks as he may desire.

e) Cement which has been unduly long in storage with the contractor or alternatively has deteriorated due to inadequate storage and thus become unfit for use in the works will be rejected by the department and no claim will be entertained. The Contractor shall forthwith remove from the work area, any cement the Engineer-in-Charge may disallow for use on work and replace it by cement complying with the relevant Indian Standards.

3.24.14.3 Steel

The Contractor shall procure mild steel reinforcement bars, high yield strength deformed (HYSD) bars, rods and structural steel, etc., required for the works, only from the main or secondary producers manufacturing steel to the prescribed specifications of Bureau of Indian Standards or equivalent and licensed to affix ISI or other equivalent certification marks and acceptable to the Engineer-in-Charge. Necessary ISI list certificates are to be produced to Engineer-in-Charge before use on works. The unit weight and dimensions shall be as prescribed in the relevant Indian Standard specification for steel.

**3.24.15.0 Supply of Construction Materials by The Employer**

As it is a single responsibility contract supply, and/or arrange all materials and services including construction and testing equipment to complete the works in all respects described in the specification, shall be under the scope of the Contractor unless otherwise specifically mentioned elsewhere in the bidding document.

**3.24.16.0 Miscellaneous General Requirements**

3.24.16.1 Dense concrete with controlled water cement ratio as per IS-code shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness.

3.24.16.2 All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.

3.24.16.3 All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti-corrosive paint to take care of sea worthiness.

3.24.16.4 A screed concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to IS:456-1978 shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.

3.24.16.5 Bricks having minimum 75 kg/cm2 compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75 kg/cm2 compressive strength before submitting his offer.

3.24.16.6 Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sun-shade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.

3.24.16.7 All stairs shall have maximum riser height of 150 mm and a minimum tread width of 300 mm. Minimum width of stairs shall be 1500 mm. Service ladder shall be provided for access to all roofs. RCC fire escape staircase shall be provided in control buildings.

3.24.16.8 Angles 50 x 50 x 6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of manhole pre-cast cover and any other place where breakage of corners of concrete is expected.

3.24.16.9 Anti termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors etc. as per IS:6313 and other relevant Indian Standards.

3.24.16.10 Hand-railing minimum 900 mm high shall be provided around all floor/roof openings, projections/balconies, walk ways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanized (medium-class as per IS:277). All rungs for ladder shall also be galvanized as per IS: 277 medium classes.
For RCC stairs, hand railing with 20 mm square MS bars, balustrades with suitable MS flats shall be provided with black PVC sheathing.

3.24.16.11 The details given in tender drawings shall be considered along with details available in this section of the specification while deciding various components of the building.

3.24.16.12 Items/components of buildings not explicitly covered in the specification but required for completion of the project shall be deemed to be included in the scope.

# 3.25 TECHNICAL SPECIFICATION OF OUTDOOR POTENTIAL TRANSFORMERS

### 3.25.1 SCOPE

3.25.1.1 his Section of the Specification covers general requirements for design, engineering, manufacture, assembly and testing at manufacturer's works of Live Tank type outdoor Potential Transformers.

3.25.1.1 Loading at manufacturer's works, transportation and delivery at respective substation site including unloading at destination site.

3.25.1.2 Erection, Testing and Commissioning of Potential Transformers.

### 3.25.2 STANDARDS

3.25.2.1 The equipment covered by this specification shall, unless otherwise stated be designed, constructed and tested in accordance with the latest revisions of relevant Indian Standards or equivalent IEC and shall conform to the regulations of local statutory authorities.

3.25.2.1 In case of any conflict between the Standards and this specification, this specification shall govern.

3.25.2.2 The potential transformer shall comply also with the latest issue of the following Indian standard.

(i). IS: 3156(Part-I): Potential transformers: General requirement.
(ii). IS: 3156 (Part-II): Potential transformers: Measuring Potential transformers
(iii). IS: 3156 (Part-III): Potential transformers: Protective Potential transformers

### 3.25.3 GENERAL REQUIREMENTS

3.25.3.1 The cores of the potential transformers shall be of high grade, non-aging CRC steel of low hysteresis loss and high permeability.

3.25.3.2 Instrument transformers shall be of **Live Tank design.**

3.25.3.3 The instrument transformers shall be truly hermetically sealed to completely prevent the oil inside the tank coming into contact with the outside temperature. To take care of oil volume variation the tenderer is requested to quote the current transformers with stainless steel diaphragm (bellow).
***All parts of bellow shall be stainless steel only***. ***A ground glass window shall be provided to monitor the position of the metal bellow.***

3.25.3.4 The instrument transformers shall be completely filled with oil.

3.25.3.5 A complete leak proof secondary terminal arrangement shall be provided with each instrument transformers. All secondary terminals shall be brought out into weather, dust and vermin proof terminal box. Secondary terminal boxes shall be provided with facilities for easy earthing, shorting, insulating and testing of secondary circuits. The terminal boxes shall be suitable for connection of control cable gland.

3.25.3.6 All instrument transformers shall be of single-phase unit.

3.25.3.7 All Instrument transformers shall be suitable for upright mounting on latticed steel structures.

3.25.3.8 The Instrument Transformer shall be complete in all respects and shall conform to the modern practice of design and manufacture.

3.25.3.9 The instrument transformers shall be so designed to withstand the effects of temperature, wind load, short circuit conditions and other adverse conditions.

3.25.3.10 All similar parts, particularly removable ones, shall be interchangeable with one another.

3.25.3.11 All cable ferrules, lugs, tags, etc. required for identification and cabling shall be supplied complete for speedy erection and commissioning as per approved schematics.

3.25.3.12 The instrument transformers shall be designed to ensure that condensation of moisture is controlled by proper selection of organic insulating materials having low moisture absorbing characteristics.

3.25.3.13 All steel work shall be degreased, pickled and phosphate and then painted in accordance with as specified in the bid document.

3.25.3.14 The outer surface of metal tank shall be Hot Dip Galvanized, whereas, the inner portion shall be painted in accordance with as specified in bid document or hot dip galvanised.

3.25.3.15 The galvanising shall be as per applicable standard IS: 2629 and minimum thickness of zinc coating shall be 610 gm/sq.mt.

### 3.25.4 INSULATING OIL

3.25.4.1 The quantity of insulating oil for instrument transformers and complete specification of oil shall be stated in the tender. The insulating oil shall conform to the requirement of latest edition of IS: 335 / IEC 60296 (required for first filling)

**3.25.5 COMMON MARSHALLING BOXES**

3.25.5.1 The outdoor type common marshalling boxes shall conform to the latest edition of IS 5039 and other general requirements specified hereunder.

3.25.5.2 The common marshalling boxes shall be suitable for mounting on the steel mounting structures of the instrument transformers.

3.25.5.3 1(One) common marshalling box shall be supplied with each set of instrument transformers. The marshalling box shall be made of sheet steel and weather proof. The thickness of sheet steel used shall be not less than 3.0 mm. It is intended to bring all the secondary terminals to the common marshalling.

3.25.5.4 The enclosures of the common marshalling boxes shall provide a degree of protection of not less than IP 55 (As per IS 2147).

3.25.5.5 The common marshalling boxes shall be provided with double hinged front doors with pad locking arrangement. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement.

3.25.5.6 Each marshalling box shall be fitted with terminal blocks made out of moulded non-inflammable plastic materials and having adequate number of terminals with binding screws washers etc. Secondary terminals of the instrument transformers shall be connected to the respective common marshalling boxes. All out going terminals of each instrument transformer shall terminate on the terminal blocks of the common marshalling boxes. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminals.

3.25.5.7 Each terminal shall be suitably marked with identification numbers. Not more than two wires shall be connected to any one terminal. At least 20 % spare terminals shall be provided over and above the required number.

3.25.5.8 All terminal strips shall be of isolating type terminals and they will be of minimum 10 A continuous current rating.

3.25.5.9 All cable entries shall be from bottom. Suitable removable gland plate shall be provided on the box for this purpose. Necessary number of cable glands shall be supplied fitted on to this gland plate. Cable glands shall be screw on type and made of brass.

3.25.5.10 Each common marshalling box shall be provided with two numbers of earthing terminals of galvanised bolt and nut type.

3.25.5.11 All steel works of common marshalling boxes shall be hot dipped galvanized.

3.25.5.12 All steel, inside and outside work shall be degreased, pickled and phosphate and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint. The colour of finishing paint shall be as follows: -

(i). Inside: Glossy White

(ii). Outside: Light Grey (Shade No. 697 of IS: 5)

**3.25.6 BUSHINGS AND INSULATORS**

3.25.6.1 Bushings and Insulators shall be of Porcelain, Solid core type. Porcelain used for the manufacture of bushings and insulators shall be homogeneous, free from defects, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

3.25.6.2 Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. Bushings shall be designed to have sufficient mechanical strength and rigidity for the conditions under which they will be used. All bushings of identical ratings shall be interchangeable.

3.25.6.3 Puncture strength of bushings shall be greater than the dry flashover value. When operating at normal voltage, there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the bushings when operating at the normal rated voltage.

3.25.6.4 The design of bushing shall be such that the complete bushing is a self-contained unit and no audible discharge shall be detected at a voltage up to a working voltage (Phase Voltage) plus 10%. The minimum creepage distance for severely polluted atmosphere shall be 25 mm/KV.

3.25.6.5 Sharp contours in conducting parts should be avoided for breakdown of insulation. The insulators shall be capable to withstand the seismic acceleration of 0.5 g in horizontal direction and 0.6g in vertical direction.

3.25.6.6 Bushings shall satisfactorily withstand the insulation level specified in data sheet.

**3.25.7 TESTS**

3.25.7.1 **Routine/Acceptance Tests (all units)**

3.25.7.1.1 All routine tests shall be carried out in accordance with relevant Standards.

All routine/acceptance tests shall be witnessed by the Purchaser/his authorised representative.

3.17.1.1.2 In addition, following tests on Current Transformers shall also be carried out as Routine Tests:

(i). Measurement of Capacitance.
(ii). Oil leakage test.
(iii). Measurement of tan delta at 0.3, 0.7, 1.0 Um/√3 and 10 kV

***3.17.1.1.3 At factory/works tests the Ten Delta shall not exceed 0.3% (at Um/√3). The same shall not exceed 0.7% at the end of warranty period (refer SCC clause 5.10.0 of Vol-1). If tan delta value of CTs exceed prescribed limit of 0.7% within warranty period, it will be considered as failure within warranty period (Tan delta & capacitance test of CTs shall be measured at 10KV at site). The bidder has to replenish failed CTs within guarantee period without any cost implication to AEGCL.***

3.25.7.2 **Type Tests**

3.25.7.2.1 The bidder shall furnish type test certificates and results for the all tests as per relevant Standards along with the bid for current and potential transformers of identical design.

**3.25.8 NAME PLATES**

3.25.8.1 All equipment shall have non-corrosive name plates conforming to requirements of IS and fix at a suitable position and indelibly marked with full particular there on in accordance with the standard adapted.
The rated current, extended current rating (if specified) along with year of manufacture must be clearly indicated on the name plate.
The rated thermal current in case of CT shall also be marked on the name plate.

**3.25.9 MOUNTING STRUCTURES**

3.25.9.1 All the equipment covered under this specification shall be suitable for mounting on steel structures. Supply of mounting structures is also in the scope of this tender.

3.25.9.2 Each equipment shall be furnished complete with base plates, clamps, and washers etc. and other hardware ready for mounting on existing steel structures.

**3.25.10 SAFETY EARTHING**

3.25.10.1 The non-current carrying metallic parts and equipment shall be connected to station earthing grid. For these two terminals suitable for 40mm X 10mm GI strip shall be provided on each equipment.

**3.25.11 TERMINAL CONNECTORS**

3.25.11.1 The equipment shall be supplied with required number of terminal connectors of approved type suitable for ACSR. The type of terminal connector, size of connector, material, and type of installation shall be approved by the Purchaser, as per installation requirement while approving the equipment drawings.

**3.25.12 PRE-COMMSIONING TESTS**

3.25.12.1 Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for

conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval:

**(a) Current Transformers**

i) Insulation Resistance Test for primary and secondary.
ii) Polarity test
iii) Ratio identification test - checking of all ratios on all cores by primary injection of current.
iv) Dielectric test of oil (wherever applicable).
v) Magnetising characteristics test.
vi) Tan delta and capacitance measurement.
vii) Secondary winding resistance measurement
viii) Contact resistance measurement (wherever possible/accessible)

**(b) Voltage Transformers**

i) Insulation Resistance Test for primary (if applicable) and secondary.
ii) Polarity test.
iii) Ratio test.
iv) Dielectric test of oil (wherever applicable).
v) Tan delta and capacitance measurement of individual capacitance stacks.
vi) Secondary winding resistance measurement

### 3.25.13 TECHNICAL DATA SHEET FOR CURRENT AND POTENTIALTRANSFORMERS

3.25.13.1 For 220,132 & 33 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired up to the terminal blocks.

### 3.25.14 TYPE AND RATING:

All potential transformer shall be outdoor type, single phase, oil immersed, self-cooled suitable for mounting on steel structure. The potential transformer shall have the following ratings and particulars.

| Item | | Ratings and Particulars | | |
|---|---|---|---|---|
| (A) | Nominal system voltage | **220kV** | **132kV** | **33 kV** |
| (B) | Highest system voltage, kV | 245 | 145 | 36 |
| (C) | Rated frequency, HZ | 50 | 50 | 50 |
| (D) | System earthing | Solidly Earthed | Solidly earth | Solidly earth |
| **(E)** | **Insulation level** | | | |
| (a) Impulse withstand voltage: kVp | | 1050 | 550 | 170 |
| (b) One-minute p.f. Withstand voltage, kV (r.m.s.) | | 460 | 230 | 70 |
| (F) Short time current for one second, kA | | 40 | 31.5 | 25 |
| (G) Minimum creepage distance, mm | | 6125 | 3625 | 1800 |
| (a) Tan Delta (for CTs only) at Um/√3,(Max) | | 0.3% | 0.3% | 0.3% |
| (H) Temperature rise | | As per ISS | | |
| **POTENTIAL TRANSFORMER** | | | | |
| (i) No. of secondary windings | | 3 | 2 | 2 |
| (ii) Transformation ratio | | | | |
| (a) | Winding I | (220 kV/√3) / (110 V/√3) | (132kV/√3) / (110V/√3) | 33kV/√3 |
| (b) | Winding II | | | / 110V/√3 |
| (c) | Winding III | | - | |
| (iii) Rated out put | | | | |

| | | | |
|---|---|---|---|
| (a) Winding I | | 500 | 200 |
| (b) Winding II | | 200 | 100 |
| (vi) Accuracy class | | | |
| (a) Winding I | | 0.2 | 0.2 |
| (b) Winding II | | 3P | 3P |
| (v) Rated voltage factor | | 1.2 | 1.2 |

**Note:**

(i) It is intended to use different ratios of the same CT at the same time for various protections and metering cores.

(ii) The CTS should therefore be suitable for the above purpose by secondary tapings only.

(iii) The ratio change by secondary taps is acceptable as long as the required CT specifications are achieved at all ratios.

(iv) The knee point voltage specified above shall be at higher ratio/ taps.

## CHAPTER 3.26: SUB STATION AUTOMATION SYSTEM

### 3.26.1 GENERAL

The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system ***which must be in satisfactory operation for at least 3 (three) years as on the date of bid opening.*** KEMA/ Internationally and nationally accreditted certificate for all IEDs and Ethernet switches conforming to IEC 61850 is to be furnished as qualification requirement.

***Please Note:*** *The integration of existing CRP to the existing SAS (Hitachi Energy make at 220kV Rangia GSS) has to be done by authorized representatives of the OEM only.*

*Any upgradation of hardware and software for above integration shall be in the scope of contractor including licence upgradation (if required) if specified in the Price Schedule or BoQ. The validity of the licence upgraded should be minimum of 10 years.*

**Standards**

**Environment Standards**

All these standards are applicable to elements like HMI, Ethernet network and elements, Gateways, IEDs.

| Type Test Name | Type Test Standard | Conditions |
|---|---|---|
| Insulation Resistance | IEC 60255-5 | 100 MΩ at 500 Vdc (CM & DM) |
| Dielectric Withstand | IEC60255-5 IEEE C37.90 | 50 Hz, 1mn, 2kV (CM), 1kV (DM) |
| | | 50 Hz, 1mn, 1kV (CM) |
| | | G 1.4 & 1.5 500V CM<br>G 6 :1,5 kV CM |
| High Voltage Impulse Test | IEC 60255-5 | 5kV (CM), 3kV (DM) |
| | | 2kV (CM) |
| | | Groups 1 to 6 :5 kV CM & 3 kV DM(1) |
| | | Not on 1.4 & 1.5 : 5 kV CM & 3 kV DM(1) |
| Free Fall Test<br>Free Fall Packaging Test | IEC 60068-2-31<br>IEC 60068-2-32 | Test Ec : 2 falls from 5cm Test Ed : 2 falls from 0,5m |
| | | 2 falls of 5 cm (Computer not powered) |
| | | 25 falls of 50 cm (1) (2) (Packaging computer) |
| Vibration Response – Powered On | IEC 60255-21-1 | Class 2 :<br>1g from 2 to 150Hz |
| | | Classe 2 :<br>Acceleration : 1g from 10 (1) to 150Hz |
| Vibration Response – Not Powered On | IEC 60255-21-1 | Class 2 :<br>2g from 2 to 500Hz |
| | | Classe 2 :<br>Acceleration : 2g from 10 (1) to 500Hz |
| Vibration Endurance – Not Powered On | IEC 80068-2-6 | Class 2 :<br>1g from 10 to 150Hz |

| Type Test Name | Type Test Standard | Conditions |
|---|---|---|
| | | Class 2 :<br>Acceleration : 1g from 10 (1) to 500Hz |
| Shocks – Not Powered On | IEC 60255-21-2 | Class 1 :<br>15g, 11 ms |
| Shocks – Powered On | IEC 60255-21-2 | Class 2 :<br>10g, 11 ms |
| Bump Test – Not Powered On | IEC 60255-21-2 | Class 1 :<br>10g, 16ms, 2000/axis |
| Seismic Test – Powered On | IEC 60255-21-3 | Class 1 :<br>Axis H : 3,5mm – 2g Axis V : 3,5mm – 1g |
| | | Classe 2 : Acceleration : 2g<br>Displacement : 7,5mm selon axe H<br>Acceleration : 1g<br>Displacement : 3,5mm selon axe V |
| Damp Heat Test - Operating | IEC 60068-2-3 | Test Ca :<br>+40°C / 10 days / 93% RH |
| Cold Test - Operating | IEC 60068-2-1 | Test Ab :<br>-10°C / 96h |
| | | Test Ab : - 25°c / 96 H |
| Cold Test - Storage | IEC60068-2-1 | Test Ad :<br>-40°C / 96h<br>Powered On at –25°C (for information)<br>Powered On at –40°C (for information) |
| Dry Heat Test – Operating | IEC 60068-2-2 | Test Bd : 55°C / 96h |
| | | 70°C / 2h |
| | | 70°c / 24 H |
| Dry Heat Test – Storage | IEC 60068-2-1 | Test Bd :<br>+70°C / 96h<br>Powered On at +70°C |
| Enclosure Protection | IEC 60529 | Front : IP=52<br>Rear : IP=30 |
| Inrush current (start-up) | | T < 1,5 ms / I < 20 A<br>T < 150 ms / I < 10 A<br>T > 500 ms / I < 1,2 In |
| Supply variation | IEC 60255-6 | Vn +/- 20%<br>Vn+30% & Vn-25% for information |
| Overvoltage (peak withstand) | IEC 60255-6 | 1,32 Vn max<br>2 Vn during 10 ms (for information) |

| Type Test Name | Type Test Standard | Conditions |
|---|---|---|
| Supply interruption | IEC 60255-11 | From 2,5 ms to 1 s at 0,8 Vn<br>50 ms at Vn, no malfunction (for information) |
| 40 s interruption | IEC 60255-11 | |
| Ripple (frequency fluctuations) | IEC 60255-11 | 12% Vn at f=100Hz or 120Hz<br>12% Vn at f=200Hz for information |
| Supply variations | IEC 60255-6 | Vn +/- 20% |
| AC Voltage dips & short interruptions | EN 61000-4-11 | 2ms to 20ms & 50ms to 1s<br>50 ms at Vn, no malfunction (for information |
| Frequency fluctuations | IEC 60255-6 | 50 Hz : from 47 to 54 Hz<br>60 Hz : from 57 to 63 Hz |
| Voltage withstand | | 2 Vn during 10 ms (for information) |
| High Frequency Disturbance | IEC 60255-22-1<br>IEC 61000-4-12<br>IEEE C37.90.1 | Class 3 : 2.5kV (CM) / 1kV (DM) |
| | | Class 2 : 1kV (CM) |
| Electrostatic discharge | IEC 60255-22-2<br>IEC 61000-4-2 | Class 4 :<br>8kV contact / 15 kV air |
| Radiated Immunity | IEC 60255-22-3<br>IEC 61000-4-3 | Class 3 :<br>10 V/m – 80 to 1000 MHz<br>& spot tests |
| | IEEE C37.90.2 | 35 V/m – 25 to 1000 MHz |
| Fast Transient Burst | IEC 60255-22-4<br>IEC 61000-4-4<br>IEEE C37.90.1 | Class 4 :<br>4kV – 2.5kHz (CM & DM) |
| | | Class 3<br>2 kV - 2,5 kHz MC |
| | | Class 3 :<br>2kV – 5kHz (CM) |
| Surge immunity | IEC 61000-4-5 | Class 4 :<br>4kV (CM) – 2kV (DM) |
| | | Class 3 :<br>2kV (CM) on shield<br><br>Class 4 :<br>4kV (CM) for information |
| | | Class 3 :<br>1 kV MC |

| Type Test Name | Type Test Standard | Conditions |
|---|---|---|
| High frequency conducted immunity | IEC 61000-4-6 | Class 3 :<br>10 V, 0.15 – 80 MHz |
| Harmonics Immunity | IEC 61000-4-7 | 5% & 10% de H2 à H17 |
| Power Frequency Magnetic Field Immunity | IEC 61000-4-8 | Class 4 :<br>50 Hz – 30 A/m permanent – 300 A/m short time |
| | | Class 5 :<br>100A/m for 1mn<br>1000A/m for 3s |
| Power Frequency | IEC 61000-4-16 | CM 500 V / DM 250 V via 0.1 µF |
| Conducted emission | EN 55022 | Gr. I, class A and B : from 0.15 to 30 MHz |
| Radiated emission | EN 55022 | Gr. I, class A and B : from 30 to 1000 MHz, 10m |

**Communication Standards**
**UCA2:**
**CASM 1.6** - Common Application Service Models and Mapping to MMS
**GOMSFE 0.91** - Generic Object Models for Substation & Feeder Equipment

**IEC 61850:**
IEC 61850-8-1: *Communication networks and systems in substations – Part 8-1: Specific communication service mapping (SCSM) – Mapping to MMS(ISO/IEC 9506 Part 1 and Part 2*

**Telecontrol protocol:**
IEC 608670-5-101
IEC 608670-5-104.
**Legacy protection protocol**
IEC 60870-5-103 *International standards – First release 1997-12*
MODBUS
**Automation Standard**

IEC 61131-3

The Substation Automation System (SAS) shall be installed, tested and commissioned to control and monitor all the sub-station equipment from remote control center (SCADA) as well as from local SCADA. The SAS shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IEDs) for Control and Monitoring.
- Bay Protection Intelligent Electronic device (IEDs) for Protection as detailed in previous chapter
- Metering server (Industrial Grade) and protocol converter.
- Station Main & Hot Standby Redundant Human Machine Interface (HMI)
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- The managed Ethernet switch shall have sufficient port redundancy (Both Fibre & Copper ports).
- The IED shall have two fiber optic ports for connecting Ethernet Switch of each LAN i.e. (PRP,architecture).

- Integrated Switches (built-in bay IEDs) are not acceptable. All the IEDs shall be directly connected to the Ethernet Interbay LAN without the use of any gateways.
- Gateway for remote control via industrial grade hardware (to SLDC) through IEC60870-5-101 & 104 protocol. All the IEDs shall be directly connected to the Ethernet PRP LAN without use of any gateways.
- The communication protocol between the bays, with the Gateway and HMI shall be UCA2/IEC 61850 in order to permit 100 Mbps peer-to-peer communications.
- Within a bay it shall be UCA2/IEC 61850 protocol.
- All IEDs shall have redundant power card.
- Gateway for Control from Remote end and State Load Dispatch Center (SLDC). The gateway should be able to communicate with SLDC on IEC 60870-5-101 & 104 protocol. The specific protocol to be implemented shall be handed over to successful bidder. It shall be the bidder's responsibility to integrate his offered system with existing SLDC system for exchange of desired data. The bidder shall ensure that proposed automation system is compatible with the existing SCADA network. Equipment required for data transfer to the existing SCADA network to interface communication equipment is in the bidder's scope of work and it will be included in the bid price.
- Gateway shall also have redundancy and redundant Gateway shall not be housed in a single cabinet. The Gateway shall also have sufficient future expandability and this shall excludes data **for all future provision bays as per Project Requirement**. The Gateways shall have redundant power cards.
- The communication link (PLCC / Fiber Optic) to SLDC is not in the scope of the bidder. However, the bidder will provide required modem both for PLCC and Fibre Optic communications to the nearest Wide Band Locations of STU/CTU which are connected to SLDC. It shall be the bidder's responsibility to integrate the offered system for desired exchange of telemetry data to SLDC.
- Redundant Local HMI & DR Work Station.
- Peripheral equipment like printers, display units, key boards, Mouse etc. 3.4.1.5. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions.
- Gateway IEDs shall have redundant power card.
- Gateway shall also have 100% redundancy for it's all functions like power, AI & BI/BO card etc. The Gateway shall also have sufficient future expandability and this shall excludes **data for all future provision bays as per Project Requirement**. The Gateways shall have redundant power cards
- **License of 15 years for the commissioned Sub Station Automation System (SAS) shall be provided.**
- **Vulnerability Audit and Penetration Testing by CERT-In empanelled firm: After successful commissioning of SAS, the successful Bidder shall do cyber Audit of the system by a CERT-In empanelled Cyber Security Auditor (to be approved by AEGCL). For that the company shall do Vulnerability assessment and Penetration testing of the SAS system and submit the report to AEGCL. The company shall fix any vulnerabilities found during the VA/PT.**

It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. **A model architecture drawing for SAS is enclosed at the end of this chapter as Annexure I.**

**Bay level intelligent electronic devices (IED) for protection and control and the Managed Ethernet Switch shall be provided in the C&R panels installed in the local control room**. Each IED will be directly connected to the Hot-standby Server PC (HMI) of the Station Automation System through a **PRP** Ethernet LAN on fiber optic medium and shall communicate as per the IEC61850 standard.

The communication gateway shall facilitate the information flow with SLDC/Remote Control Centre.
The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.
The Integration of IEC61850 communication based monitoring equipment like Online Insulating Oil drying system, Digital RTCC Relays etc with substation automation system shall be carried out and shall be included in the scope of work.
Further the Gateways shall have licenses sufficient for all the bays covered in the present scope as well as all the mentioned future bays.
All the numerical IEDs must be fully IEC 61850 compliant and must have the following features.

- Have peer-to-peer communication using GOOSE messages (IEC 61850) for interlocking.
- Should be interoperable with third party IEC 61850 compliant devices
- Should generate XML file for integration/engineering with vendor independent SCADA systems.
- **Should be directly connected to the inter bay bus on IEC 61850 without the use of any gateways.** Connections of bay protection IEDs to the IEC 61850 bus through the bay control units is not acceptable.

### 3.26.2. SYSTEM DESIGN

**General System Design**

- The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including **all future extensions as per Project Requirement**..
- The systems shall be of the state-of-the art architecture and shall be suitable for operation under electrical environment present in Extra high voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.
- The offered SAS shall support remote control and monitoring from remote SCADA via gateways.
- The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.
- The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signaling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.
- Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.
- **Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated isolator, earth switches and instrument transformer), bay mimic along with relay and protection panels and Station HMI in Control Room building for overall optimization.**

### 3.26.3. Ethernet Switches

Ethernet switches that fulfill the hardened requirements concerning temperature, power supply (80-250 V DC from the Station Battery) **and complying to IEC 61850** suitable to be installed in substations shall be provided, i.e. the same data as common for numerical protection. **The Managed Ethernet Switch shall have dual Power supply provision**. The use of Ethernet Hubs is not permitted as they do not provide collision free transmission. Suitable port monitoring software shall be provided for monitoring of ports healthiness and should generate alarm in SAS.

## 3.26.4. SYSTEM ARCHITECTURE

- The SAS shall be based on a PRP architecture and on a concept of bay-oriented, distributed intelligence.
- The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.
- At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers. But incase of Circuit Breaker SF6 Gas Pressure, Operating Mechanism Pressure (i.e. Air/ Pneumatic, Hydraulic and Nitrogen Pressures), if SF6 CTs are Utilizing the Pressure of SF6 Gas, Transformer Oil/ Winding temperatures, fire fighting or any Other with Transformer management Relay and OLTC Tap Position & Operation can be interfaced with BCU or any Other device interface through Transducers. The tap changing operation, synchronization of sources and trip transfer operation shall be performed through the BCU in addition to above. These parameters shall appear in Substation Automation System at Local HMI.
  **In GIS Sub Stations, all the gas tight chambers are required to be monitored individually phase wise for their SF6 gas density status by the bay control unit in a bay. Sufficient numbers of inputs are required to be provided in the BCU for the all the signals from the GIS Bays. In case there is any limitation of number of inputs in the BCU, additional BCUs or additional Cards( In case of Modular BCU) are required to be provided without any cost implication to AEGCL. These inputs shall be used for necessary monitoring, control and protection purpose.**

  The Sub-station Automation system being offered shall generally conform to provision of IEC 62351, IEEE1686 and NERC CIP (applicable part such as CIP 003, CIP-005, and CIP-007) for cyber security.

- **Tagging for Report generation shall be provided for sufficient number of signals for incorporation of all present and future bays, including 20% spare.**
- Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.
- The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fiber optic cables, thereby guaranteeing disturbance free communication. Data exchange is to be realized using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure.
- The communication shall be in parallel mode, and such that failure of one set of fiber shall not affect the normal operation of the SAS. However, it shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers. IED shall have two fibre ports and one port shall be connected to individual Ethernet Switch of each LAN.
- At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.

- Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. **The priority shall always be on the lowest enabled control level.**
- The station level contains the station-oriented functions, which cannot be realized at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centers.

- The GPS time synchronizing signal for the synchronization of the entire system with redundancy shall be provided.
- The SAS shall contain the functional parts as described in para above.

### 3.26.5. FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

- ✓ Remote control centers/SLDC
- ✓ Station HMI.
- ✓ Local Bay controller IED

Operation shall be possible by only one operator at a time.
The operation shall depend on the conditions of other functions, such as interlocking, synchro check etc.

**Select-before-Execute**

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

**Command Supervision**

**Bay/station interlocking and blocking**
Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.
It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays.
For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.
A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

**Run Time Command Cancellation**
Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

**Self-supervision**
Continuous self-supervision function with self-diagnostic feature shall be included.

**User Configuration**
The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.
It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:
a). Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions
b). System Level Functions

### 3.26.6. BAY LEVEL FUNCTIONS

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions **including data collection in bay control / protection unit**.
- Bay protection functions with support of Numerical Relays defined in CRP Section.

### 3.26.7. Bay Control Functions

**Overview**

**Functions:**

- Control mode selection
- Select-before-execute principle
- Command supervision:
  - ✓ Interlocking and blocking
  - ✓ Double command
- Synchro-check, voltage selection
- Run Time Command cancellation
- Transformer Tap Changer control (raise / lower tap) (for Power Transformer bays)
- Operation counters for Circuit Breakers and Pumps.
- Transformer cooling gear, pump control and runtime supervision
- Operating pressure Monitoring & supervision (CB SF6 Gas Pressure, CB Operating Pneumatic Pressure / spring status).
- Display of interlocking and blocking
- Breaker position indication (per phase for single pole)
- Alarm annunciation
- Measurement display. (Electrical Parameters & Transformer Parameters)
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 500 events
- Extension possibilities with additional I/O's inside the unit or via fiber optic communication and process bus

**Control mode selection**

**Bay level Operation**:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

**EMERGENCY Operation**

**It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED.**

**REMOTE mode**

Control authority in this mode is given to a higher level (Remote SCADA) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

**Synchronism and energizing check**

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- Settable voltage, phase angle, and frequency difference.
- Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.
- Synchronizing between live line and live bus with synchro-check function

**Voltage selection**

The voltages relevant for the Synchro-check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

**Transformer Tap Changer control**

Raise and lower operation of OLTC taps of Transformer shall be facilitated through Bay controller IED.

**Protection Transfer Control**

From BCU, necessary control shall be provided for transferring bay to TBC.

### 3.26.8. Bay Protection Functions

**General**

The Protection functions are independent of Bay Control function. The Protection shall be provided by separate Protection IEDs (numerical relays) and other Protection devices as per section Relay & Protection.

IEDs shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

**Event and disturbance recording function**

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. This shall give alarm if 70% memory is full. The disturbance recorder function shall be as detailed in section C&R.

**Bay Monitoring Functions**

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

### 3.26.9. SYSTEM LEVEL FUNCTIONS

**Status Supervision**

- Continuous monitoring of switching objects i.e. the position of each switchgear, e.g. Circuit Breaker, Isolator, Earthing Switch, Transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station
- HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

- The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.
- The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through dedicated one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

**Measurements**
Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms, Max / Min values for voltage (U) and current (I) shall be calculated.

In case of Circuit Breaker SF6 Gas Pressure, Operating Mechanism Pressure (i.e. Pneumatic, Spring), if SF6 CTs are Utilizing the Pressure of SF6 Gas, Transformer Oil/ Winding temperatures, Firefighting or any Other with Transformer management Relay and OLTC Tap Position can be interfaced with BCU through Transducers. Max / Min values for the above parameters shall be calculated. These parameters shall appear in Substation Automation System at Local HMI and can monitor regularly.

The measured values shall be displayed locally on the station HMI and in the control center. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds**.**

Threshold limit values shall be selectable for alarm indications.
**The SAS shall also poll data from the Meter Server to gateway for onward communication to RCC.**

**Event and alarm handling**
Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. **The tentative list of event/ alarm for various feeders and systems are enclosed as Annexure-II and is not exhaustive, there may be addition during detail engineering or at the time of commissioning.**

### 3.26.10. Station HMI

**Substation HMI Operation:**
On the HMI the object has to be selected first. In case of a blocking or interlocking condition are not met; the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.
Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

**Presentation and dialogues**

**General**
The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks or keyboard commands.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.
An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.
The following standard pictures shall be available from the HMI:

- ✓ Single-line diagram showing the switchgear status, Pressure values (wherever required) and measured values (current, voltage, apparent power, freq & pf) including OLTC Tap Position, WTI, OTI & Analog set values.
- ✓ Control dialogues with interlocking and blocking details. This control dialogue shall tell the operator whether the device operation is permitted or blocked & Select before Execute.
- ✓ Measurement dialogues, Statistics & Trends
- ✓ Bay wise interlock status display and failure of any interlock within the bay by generating alarm and indication in Interlock diagram window.
- ✓ Alarm list, station / bay-oriented
- ✓ Event list, station / bay-oriented
- ✓ Substation Auxiliaries
- ✓ System status
- ✓ Printing of sequence of event list, hardcopy and reports. The reports shall be freely configurable using Crystal Report

List of signals to be configured in SAS is mentioned in Annexure-II of this chapter.

**HMI design principles**

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.
The object status shall be indicated using different status colours for:

- ✓ Selected object under command
- ✓ Selected on the screen
- ✓ Not updated, obsolete values, not in use or not sampled
- ✓ Alarm or faulty state
- ✓ Warning or blocked
- ✓ Update blocked or manually updated
- ✓ Control blocked
- ✓ Normal state

**Process status displays and command procedures**

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.
In addition to above Transformer WTIs, OTI, SF6 gas Pressures of Circuit breakers , CTs and CB Operating mechanism Pressures shall also be displayed.
In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted**.** After the “execution” of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.
After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

**System Supervision and Display**
The SAS system shall be comprehensively self-monitoring such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure, protection couplers and remote communication links, and printers at the station level, etc.

**Event List**
The event list shall contain events that are important for the control and monitoring of the substation.
The event and associated time (with 1ms resolution) of its occurrence has to be displayed for each event.
The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.
A printout of each display shall be possible on the hard copy printer/Dot matrix Printer / Line Printer of 132 Column.
The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.
The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurand.
- Loss of communication.
- Hourly time Stamping

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

**Alarm List**
Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).
Filters for selection of a certain type or group of alarms shall be available as for events.

**Object picture**
When selecting an object such as a circuit breaker or isolator in the single line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking
- Authority
- Local / remote control
- SLDC / SAS control
- Errors
  etc. shall be displayed.

**Control dialogues**
The operator shall give commands to the system by means of mouse click located on the single-line diagram. It shall also be possible to use the keyboard for command activation. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and Disconnector
- Transformer tap-changer

**User-authority levels**
It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorization group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear), Shift wise operator's pass word for 3 shift in a day.
- Restricted operation (e.g. by-passed interlocking)
- System administrator
- For maintenance and engineering purposes of the station HMI, the following authorization levels shall be available:
- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the login procedure. Only the system administrator shall be able to add/remove users and change access rights.

### 3.26.11. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

Trend reports:

- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak)
- Historical reports of selected analogue Values:
- Day (at 15 minutes interval)
- Week
- Month
- Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications.

v. Equipment operation details shift wise and during 24 hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperatures (WTIs, OTI) and status of pumps and fans for transformers.

vii. Printout on adjustable time period as well as on demand system frequency and average frequency.

viii. Reports in specified formats which shall be developed by the contractor.

**Trend Display (historical data)**

It shall be possible to illustrate all types of process data as trends – input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

**Automatic Disturbance File Transfer**

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

**Disturbance Analysis**

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

**IED Parameter Setting**

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

**Automatic Sequences**
The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

## 3.26.12. GATEWAY

**Communication Interface**
The Substation Automation System shall have the capability to support simultaneous communications with SLDC,
The Substation Automation System shall have communication ports as follows:
(a) Two Ports for RCC & State Load Dispatch Centre from each Gateway.
(b) The redundant Gateway shall work as hot stand by.
The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centers (SLDC).

**SLDC Communication Interface**
Employer will supply communication channels between the Substation Automation System and the SLDC. The communication channels provided by Employer will consist either of power line carrier or optical fiber.

**Interface equipment:**
The Contractor shall provide interface equipment for communicating between Substation Automation system and State Load Dispatch Centre (PLCC/ FO).
In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. **The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel**. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder except the communication link along with communication equipment between substation control room and SLDC.

**Communication Protocol**
The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101,104 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc.

## 3.26.13. SYSTEM HARDWARE

**Redundant Station HMI, and Disturbance Recorder Work station).**
The contractor shall provide redundant station HMI in hot standby mode. **The servers used in these work stations shall be of industrial grade.**

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features. The RAM, Hard Disk and Bus should latest and with maximum Values.
The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:
1) Storage of all analogue data (at 15 Minutes interval) and digital data including alarm, event and trend data for thirty (30) days,
2) Storage of all necessary software,
3) 500GB space for EMPLOYER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

**HMI (Human Machine Interface**)
The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user-friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

For 400kV,220kV, 132kV Substations 70mm VDU high resolution screen showing total SLD, alarm, bay wise real time data to be displayed as shown in the model SAS architecture.
**Visual Display Units/TFT's (Thin Film Technology)**
The contractor shall provide three display units, one for station HMI, one for redundant HMI and one for DR work station. These shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 25" diagonally (3:4) in size or more and capable of colour graphic displays.
The display shall accommodate resolution of 1280 X 1024 pixels or more.

**Printer**
It shall be robust & suitable for operation with a minimum of 132 characters per line for Line Printer and Dot Matrix Printer. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.
The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.
**All printers mounted in the control room shall be provided with printer enclosure.** The enclosure shall be designed to permit full enclosure of the printers at a convenient level. Plexiglas windows shall be used to provide visual inspection of the printers and ease of reading. The printer enclosures shall be designed to protect the printers from accidental external contact & each should be removable from hinges at the back and shall be provided with lock at the front.
All reports and graphics prints shall be printed on **laser printer**

**One Dot Matrix Printer (DMP)** shall be exclusively used for hourly log printing.

**Line printer for Events and Alarms Printing**
All printers shall be continuously online through directly or printer server.

**Mass Storage Unit**

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit of CD-ROM & DVD-ROM with 5GB or more capacity i.e CD Writer & DVD Writer (Both). The unit should support at least Read (48X), Write (24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet File systems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software**.**
All the data pertaining to Substation is to store in a system year/ month / day wise. The daily data is stored in a day file of Particular Month and Year automatically from 00.00Hrs to 24.00Hrs.

**Auxiliary BCU**
One BCU shall be put in Station level for monitoring Station Auxiliary Supply (AC & DC), Battery Chargers, Nitrogen Fire Fighting System, Fire alarm etc.

Furniture required for HMIs, Printers, and Operators etc. The make of furniture shall be of Godrej or better.

### 3.26.14. EXTENDIBILITY IN FUTURE

Offered substation automation system shall be suitable for extension in **future for all Future Bays as per Project Requirement.** During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future..

### 3.26.15. SOFTWARE STRUCTURE

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder shall not force a shut-down of the parts of the system which are not affected by the system adaptation.

### 3.26.16. Station Level Software

**Human-Machine Interface (HMI)**
The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

### 3.26.17. Bay Level Software

**System Software**
The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically

synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

**Application software**

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.

The application software within the control/protection devices shall be programmed in a functional block language.

**Simulation**

Simulation tools shall be provided with the system to emulate a missing equipment on UCA2/IEC61850. The simulation tools shall be set up by the system configuration tool and be able to execute scenario defined by the user.

### 3.26.18. Network Management System

The contractor shall provide a network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occur
(d) Provide facility to add and delete addresses and links

The bidder shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

### 3.26.18(a) Cyber Security features

wherever applicable All Intelligent electronic equipment, Numerical relays, Bay control units, Bay protection units, Gateways, Transformer Tap controller/changer, etc. with IEC 61850 communication protocol shall be cyber security compliant as per latest “CEA (Cyber security in power sector) Guidelines”. Specifications shall also be compliant to latest revision of IEEE 1686

### 3.26.19. TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV substation equipment and specified conditions:

**Type Tests:**

**Control IEDs and Communication Equipment:**

**a. Power Input:**

i. Auxiliary Voltage
ii. Current Circuits
iii. Voltage Circuits

iv. Indications

**b. Accuracy Tests:**

i. Operational Measured Values
ii. Currents
iii. Voltages
iv. Time resolution

**c. Insulation Tests:**

i. Dielectric Tests
ii. Impulse Voltage withstand Test

**d. Influencing Quantities**

i. Limits of operation
ii. Permissible ripples
iii. Interruption of input voltage

**e. Electromagnetic Compatibility Test:**

i. 1 MHZ. burst disturbance test
ii. Electrostatic Discharge Test
iii. Radiated Electromagnetic Field Disturbance Test
iv. Electrical Fast transient Disturbance Test
v. Conducted Disturbances Tests induced by Radio Frequency Field
vi. Magnetic Field Test
vii. Emission (Radio interference level) Test.
viii. Conducted Interference Test

**f. Function Tests:**

i. Indication
ii. Commands
iii. Measured value Acquisition
iv. Display Indications

**g. Environmental tests:**

i. Cold Temperature
ii. Dry Heat
iii. Wet heat
iv. Humidity (Damp heat Cycle)
v. Vibration
vi. Bump
vii. Shock

**Factory Acceptance Tests:**

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted.

The manufacturing phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. If the FAT comprises only a certain portion of the system for practical reason, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

**Integrated Testing**

The integrated system tests shall be performed as detailed in subsequent clauses as per following configuration:

- Redundant Station HMI, DR work station, two switches ( i.e. for two diameter) along with all IEDs for the Dia and printers.

All other switches for complete sub-station shall be simulated as needed.

**Hardware Integration Tests:**

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests.

**Integrated System Tests:**

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

**Site Acceptance Tests:**

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. **The successful bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.**

## 3.26.20. SYSTEM OPERATION

**Substation Operation**

**NORMAL OPERATION**

Operation of the system by the operator from the remote SLDC or at the substation shall take place via industry standard HMI (Human Machine interface) subsystem consisting of graphic colour VDU, a standard keyboard and a cursor positioning device (mouse). The coloured screen shall be divided into 4 fields :

i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication
iv) Real time bus energization status with distinguishable colours i.e. for live & dead section of SLD.

For display of alarm annunciation, lists of events etc a separate HMI View node. shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and
- Prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.
Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.
The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

### 3.26.21. POWER SUPPLY

Power for the substation automation system shall be derived from substation 220/110V DC system.
Inverter of suitable capacity shall be provided for station HMI and its peripheral devices e.g. printer etc.
In the event of Power failure, necessary safeguard software shall be built for proper shutdown and restart.

### 3.26.22. DOCUMENTATION

The following documents shall be submitted for employer's approval during detailed engineering:
(a) System Architecture Drawing
(b) Hardware Specification
(c) Sizing Calculations of various components
(d) Response Time Calculation
(e) Functional Design Document
(f) Clear procedure describing how to add an IED/ bay in future covering all major suppliers
The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look / feel. All CAD drawings to be provide in "dxf" format and also acrobat format.

- List of Drawings
- Substation Automation System Architecture
- Block Diagram
- Guaranteed Technical parameters, Functional Design Specification and Guaranteed availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels
- Logic Diagram (hardware & software )
- Control Room Lay-out
- Test Specification for Factory Acceptance Test (FAT)
- Product Technical Manuals
- Application Manuals
- Assembly Drawing
- Operator's Manual
- Testing and Commissioning Manuals
- Complete documentation of implemented protocols between various elements

- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built documents/drawings shall be provided.

## 3.26.23. TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

**Training at Contractor's Premises**

The contractor shall arrange on its own cost all hardware and software training platform required for successful training and understanding in India. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

The contractor shall provide training comprehensively covering following courses.

| S. No. | Name of Course | Participants from Employer | Duration |
|---|---|---|---|
| 1 | Computer System Hardware | 2 per sub-station | 7 day |
| 2 | Computer System Software | 6 per sub-station | 7 day |
| 3 | Application Software | 2 per sub-station | 7 day |

A. Computer Hardware Course: The course will contain configuration of system hardware, equipment maintenance and diagnostic procedure of each element of the SAS including modems, routers, processors, technique for system expansion, and maintenance of IEDs. It will be a hand-on training.

B. Computer System Software Course: The course will cover programming language, OS software, network software, database software, system configuration, development of logic circuits. This will also be a hands-on training

C. Application Software: It will also a hands-on training and the course will contain application software and data flow, associated maintenance and expansion training,
preparation and integration of new software etc.

**Training offered shall be free of cost to the Employer except the logistic.**

**On Site Training:**

After successful commissioning of the entire SAS, the contractor will impart on-site training in following areas:

| S. No. | Name of Course | Participants from Employer | Duration |
|---|---|---|---|
| 1 | Computer System Hardware | 2 per sub-station | 7 day |
| 2 | Computer System Software | 6 per sub-station | 7 day |
| 3 | Application Software | 2 per sub-station | 7 day |

Hands on training logic development, system configuration for extension of addition of bay, IED fault finding, trouble shooting, data analysis, changing of equipment parameters/ input data, preventive maintenance of each equipment

The site training will be also of similar nature as outlined in the previous clause, except that here the training will be on actual commissioned system and all aspects shall be covered. The training shall be conducted at each substation separately, covered in the package.

The Contractor shall submit the training modules for approval of the Employer. The training durations mentioned above is tentative only. Actual duration of the training shall be as per approved training module.

## 3.26.24. MAINTENANCE

**Maintenance Responsibility during Pre-Commissioning and Commissioning Activities**
During Pre-Commissioning and Commissioning activities, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational.

**Maintenance Responsibility during Guarantee Period**
During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days free of any charge to the Employer.

## 3.26.25. RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electrical interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
- Experience of security requirements
- Process know-how
- Select before execute at operation
- Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel grounding immune against transient ground potential rise

**Outage terms**
**1) Outage**
The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause above due to an event directly related to the SAS or unit of SAS. In the event, the Employer has taken any equipment/ system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

**2) Actual outage duration (AOD)**
The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest 1/4th of an hour. Time less than 1/4th of an hour shall be counted as having duration of 1/4th of an hour.

**3) Period Hours (PH)**
The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

**4) Actual Outage hours (AOH)**
The sum of actual outage duration within the reporting period AOH = Σ AOD

**5) Availability**
Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

## 3.26.26. GUARANTEES REQUIRED

**The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole during the pre-commissioning and commissioning periods.** The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 700 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 700 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.
The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.
After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start along with the whole facilities.

## 3.26.27. SPARES

**Consumables**
All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the Employer.

**Availability Spares:**
In addition to mandatory spares as listed in below for SAS, the bidder is required to list the recommended spares along with unit prices, which may be required for ensuring the guaranteed availability of the system. During the entire guarantee period including the pre-commissioning and commissioning periods, the successful contractor will have to make available at site his recommended spares.
Based on the requirement of recommended spares during the entire guarantee period, the Employer will decide the final list of spares that the Employer will procure for safe running of the system after the guaranteed period. The contractor is bound to supply these spares promptly.

**LIST OF MANDATORY SPARES**

(a) FO cables with terminations for each type and length between IEDs (One FO cable for each type/length).
(b) Patch/Cu cable with terminations of each type and length between IEDs of Station level (One cable for each type/length)
(c) Any interface/Protocol converter (One for each type).
(d) BI/BO card for each type of IED (one no each).
(e) Power card for each type of IED (one no each).
(f) Transducers of each type (one no each)
(g) Industrial grade computer. (one number)

### 3.26.28. Major Component of SAS

Following minimum equipment shall comprise the Substation Automation System.

i) Station HMI & Redundant Station HMI (in Hot-stand by mode) of Latest Configuration and Latest OS Software with CD & DVD Multilayer Read, write, Rewrite with Possible all types of formats, Hard disk capacity of 1TB, Key Board, Optical Mouse, integrated VGA, Integrated LAN, 25" or More TFT Monitor (4:3 Screen).
ii) Engineering Station & Disturbance Recorder Work Station (Maintenance HMI)
iii) Gateways with PLCC/Fibre Optic Modem
iv) Required Inverter/UPS for 3 hour back up
v) List of Printers with / without Printer server
1. Colour Laser Printer– 1 No. (Print, Scan, Fax & Xerox) (For Reports & Disturbance records),
2. Line Printer - (For Alarms and Sequence of Event recorder)
3. Dot matrix printer Multi sheet paper Model – For log sheets, regular parameters at 15 min duration).
vi) All interface equipment for gateway to SLDC.
vii) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required. (Armoured FO and Cu Cables) as required.
viii) BCUs for Sub Station Auxiliaries.
ix) Any other equipment as necessary.
For all the SAS equipment, the power supply unit shall have dual mode i.e. main & redundant card, in case of any one card fail, the IED/Component of SAS shall have to switch over to redundant card and to generate alarm for the outage of the card.
**All the type of cables used for LAN (Bay level & Station level) shall be Armoured type**.

### 3.26.29. Erection, Testing & Commissioning

a) **The bidder shall depute their Engineer to the various sites for carrying out the testing and commissioning of C&R panel**.

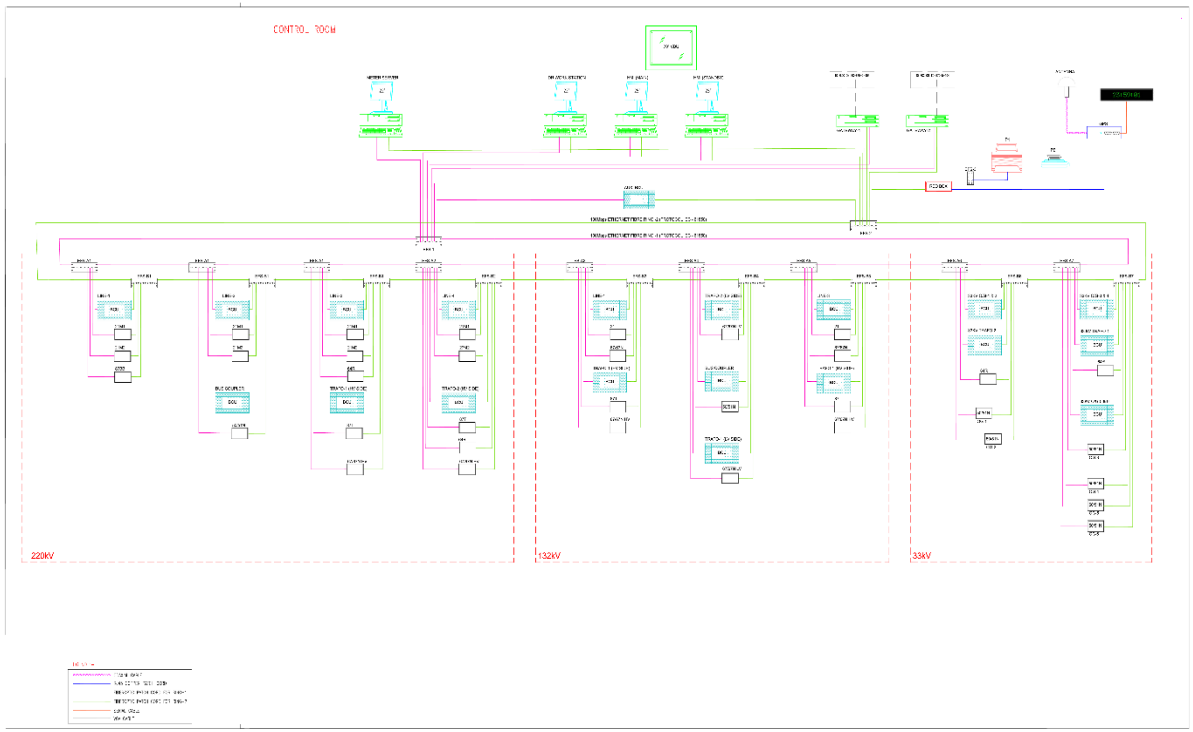
### 3.26.30. GUARANTEES REQUIRED

**The availability for the complete SAS shall be guaranteed by the Contractor.**
**The Guarantee period will be stipulated for 1 year and beyond which Annual Maintenance Contract (AMC) will come into force.**
**Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole during the pre-commissioning and commissioning periods.**
The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 700 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 700 Hours

period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.
The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.
After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start along with the whole facilities.

AMC shall be started after warranty period is over. During AMC, Manufacturer Engineer shall have to visit half yearly or as and when defects are developed. For any defects developed, Engineers are to attend the defects within three (3) working days of reporting. **The entire cost incurred for attending the issues raised/the regular yearly, half yearly visits shall be covered under the AMC. Manufacturer has the responsibility to take care of replacement of all items if required to restore the system**. During AMC, if any element is added up, integration of same is the responsibility of Manufacturer without any cost involvement to Employer.

## ANNEXURE-I: SAS Architecture



Notes:

1) The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.

2) The IEDs for control, protection & metering (ABT compliant electronic TVM) shall be installed in the swing type simplex C & R panels inside the control room, all connections shall be realized as per IEC 61850 protocol.

3) Required Inverter of Numeric make, 3 KVA capacity shall be provided by the bidder.

**4) Necessary furniture for installation of complete equipment of SAS is also in the scope of supply. The successful bidder shall submit list of complete furniture including enclosure for printers.**

5) For gateway, it shall communicate with Remote Control Centre and State Load Despatch Centre (SLDC) on IEC 60870-5-101 & 104 protocol.

6) The SLD displayed in the HMI shall be capable of distinguishing the Bus for different voltage level, bus live & dead status, bay equipment live & dead status and future extension indicating through different colours.

7) The printers shall be connected to station bus directly and can be managed from station HMI, as well as disturbance recorder work station.

The above Architecture is typical. The contractor is to consider the SLD of respective substation for detail BoQ, particularly for Ethernet Switches & BCUs.

**ANNEXURE II**

**List of Analogue and Digital Inputs/ Outputs for SAS**

1. **Basic Monitoring requirements are:**

o Switchgear status indication
o Measurements (U, I, P,MVA Q, f, sequence components, pf, phase angle, THD & TDD, Synchrocheck information i.e. ΔF, ΔV, Δφ; Active & Reactive energy)
o Event
o Alarm
o Winding temperature if transformers/ reactors
o Ambient temperature
o Status and display of station auxiliary ac & dc supply
o Status display of transformer fire protection system
o Acquisition of all counters in PLCC panels
o from PLCC or independently by counting the receive/send commands
o Acquisition of alarm and fault record from protection relays
o Disturbance records
o Monitoring the state of batteries by displaying DC voltage, charging current and load current etc for both 220/110-volt station & communication 48-volt batteries
o Tap-position of Transformer

**2. List of Inputs:** The list of input for typical bays is as below:-

1) **Analogue inputs**

- For line R, Y, B phase line currents & R-N, Y-N, B-N phase voltages
- For transformers R, Y, B phase line currents for HV & LV
  - OTI & WTI
  - Tap position
- For bus coupler R, Y, B phase line currents
- Common
  - R-N, Y-N, B-N phase voltages for all buses
  - Frequency of all buses
  - Outside ambient temperature
  - LT ac voltages
  - 220/ 110-volt station battery voltage
  - 48-volt battery voltage

**2) Digital inputs**

- Line bays
  - Status of each pole of CB
  - Status of isolator, earth switch
  - CB trouble
  - CB operation / closing lock out
  - Pole discrepancy operated
  - Trip circuit faulty
  - LBB operated
  - Bus bar protection trip operated

- Breaker auto reclosure operated
- Tie/ transfer breaker auto reclosure operated
- AR lock out
- Trip transfer sent/ received
- Main I / II DPR operated
- Directional E/F operated
- Fuse failure alarm
- PSB alarm
- Broken Conductor alarm
- Under voltage alarm
- SOTF trip
- Carrier aided trip
- Main I/ II Zone 2/ Zone III trip
- Back up O/C or E/F operated
- PLCC protection channel I/ II failed
- PLCC speech failed
- BCU/ BPU failed

➢ Transformer bays

- Status of CB, isolator, earth switch
- CB trouble
- CB operation/ closing lock out
- Pole discrepancy operated
- Trip circuit I/ II faulty
- BCU/ BPU failed
- LBB operated
- Bus bar protection operated
- REF operated
- Differential operated
- Over flux alarm/ trip
- OTI/ WTI alarm/ trip
- Buchholz alarm/ trip
- OLTC OSR trip
- Low oil alarm
- PRD I/ II operated
- Back up O/C or E/F operated
- Zero sequence current
- Discrimination of PT fuse fail and circuit dead

➢ Bus bar Protection

- Bus bar main I/ II trip
- Bus bar zone I/II open
- Bus protection relay fail
- BCU/ BPU failed

**Other Signal to be incorporated in DR/SAS:**

Standard DR Signal

**1. For transmission Line (One & half breaker scheme)**

| | **MAIN-1** | - |
|---|---|---|
| **A** | **Configuration of ANALOG CHANNELS** | |
| **S.No.** | **Channel Description** | **Standardized Channel Name** |
| 1 | R Phase Current | I-R PH. |
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH. |
| 5 | R Phase Voltage | V-R PH. |
| 6 | Y Phase Voltage | V-Y PH. |
| 7 | B Phase Voltage | V-B PH. |
| 8 | Open Delta Voltage | V-N (Open Delta) |

| **B** | **Configuration of Digital Channels for 32 channels** | | | | |
|---|---|---|---|---|---|
| **S.No.** | **Channel Description** | **(Limited to 16 Characters)** | **7 characters** | **Triggers** | **COMMENTS** |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y | |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y | |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y | |
| 4 | TIE CB R-PHASE OPEN | TIE_CB_R_OPEN | T CB_RO | Y | |
| 5 | TIE CB Y-PHASE OPEN | TIE_CB_Y_OPEN | T CB_YO | Y | |
| 6 | TIE CB B-PHASE OPEN | TIE_CB_B_OPEN | T CB_BO | Y | |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y | |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y | MAIN-2 |
| 9 | AUTO RECLOSE OPTD MAIN CB | MAIN_CB_A/R_OPTD | M CB_AR | Y | |
| 10 | MAIN CB AR LOCKOUT | MAIN CB AR LO | MCB AR LO | N | |
| 11 | AUTO RECLOSE OPTD TIE CB | TIE_CB_A/R_OPTD | T CB_AR | Y | |
| 12 | TIE CB AR LOCKOUT | TIE CB A/R_LO | AR_L/O | N | |
| 13 | MAIN1/2 CARRIER RECEIVE | MAIN1/2_CARR_REC | M1/2_CR | N | MAIN-1/2 |
| 14 | DT RECEIVE CHANNEL-1/2 | DT_REC_CH1/2 | DTRC1/2 | Y | |
| 15 | 3 PH. GROUP A/B OPERATED | 3PH_GR_A/B_OPTD | GRA/B_OPD | Y | |
| 16 | OVER VOLTAGE STAGE-1 OPERATED | O/V_STG1_OPTD | O/V_ST1 | Y | |
| 17 | OVER VOLTAGE STAGE-2 OPERATED | O/V_STG2_OPTD | O/V_ST2 | Y | |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 18 | POWER SWING BLOCK OPERATED | PS BLK OPTD | PSB_OP | N | |
| 19 | STUB/TEED OPERATED | STUB_OPTD | SB_OPD | Y | Where ever Applicable |
| 20 | BUSBAR OPERATED (M1/M2) | BUSBAR_OPTD | BB_OPD | Y | |
| 21 | MAIN/TIE LBB OPERATED | M/T_LBB_OPTD | M/T_LBB | Y | |
| 22 | MAIN 1 ZONE-1 OPTD. | MAIN1_Z1_OPTD | M1Z1_OP | Y | |
| 23 | MAIN 1 ZONE-2 START | MAIN1_Z2_START | M1Z2_ST | N | |
| 24 | MAIN 1 ZONE-2 OPTD. | MAIN1_Z2_OPTD | M1Z2_OP | Y | |
| 25 | MAIN 1 ZONE-3 START | MAIN1_Z3_START | M1Z3_ST | N | |
| 26 | MAIN 1 ZONE-3 OPTD. | MAIN1_Z3_OPTD | M1Z3_OP | Y | |
| 27 | MAIN 1 REVERSE ZONE OPTD | MAIN1_ZR_OPTD | M1ZR_OP | Y | |
| 28 | MAIN 1/2 SOTF OPTD | M1/2_SOTF_OPD | M12SOTF | Y | |
| 29 | MAIN 1/2 DEF OPTD | DEF_OPD | DEF_OPD | Y | MAIN-1/2 |
| 30 | MAIN1/2 CARR. SEND | M1/2 CARR. SEND | M12CRSD | N | MAIN-1/2 |
| 31 | DIRECT TRIP SEND | DIR_TR SEND | DT_SEND | Y | |
| 32 | CARRIER AIDED TRIP | CARR_AID_TRIP | CAR_AID | Y | |

| | MAIN-2 | |
|---|---|---|
| A | Configuration of ANALOG CHANNELS | |
| S.No | Channel Description | Standardized Channel Name |
| 1 | R Phase Current | I-R PH. |
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH. |
| 5 | R Phase Voltage | V-R PH. |
| 6 | Y Phase Voltage | V-Y PH. |
| 7 | B Phase Voltage | V-B PH. |
| 8 | Open Delta Voltage | V-N (Open Delta) |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y | |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y | |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y | |
| 4 | TIE CB R-PHASE OPEN | TIE_CB_R_OPEN | T CB_RO | Y | |
| 5 | TIE CB Y-PHASE OPEN | TIE_CB_Y_OPEN | T CB_YO | Y | |
| 6 | TIE CB B-PHASE OPEN | TIE_CB_B_OPEN | T CB_BO | Y | |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y | MAIN-1 |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y | |
| 9 | MAIN 2 ZONE-1 OPTD. | MAIN2_Z1_OPTD | M2Z1_OP | Y | |
| 10 | MAIN 2 ZONE-2 START | MAIN2_Z2_START | M2Z2_ST | N | |
| 11 | MAIN 2 ZONE-2 OPTD. | MAIN2_Z2_OPTD | M2Z2_OP | Y | |
| 12 | MAIN 2 ZONE-3 START | MAIN2_Z3_START | M2Z3_ST | N | |
| 13 | MAIN 2 ZONE-3 OPTD. | MAIN2_Z3_OPTD | M2Z3_OP | Y | |
| 14 | MAIN 2 REVERSE ZONE START | MAIN2_ZR_START | M2ZR_ST | N | |
| 15 | MAIN 2 REVERSE ZONE OPTD | MAIN2_ZR_OPTD | M2ZR_OP | Y | |
| 16 | POWER SWING DET. | PS_DETECTED | PS_DET | N | |
| 17 | POWER SWING BLOCK OPERATED | PS BLK OPTD | PSB_OP | N | |
| 18 | OVER VOLTAGE STAGE-1 OPERATED | O/V_STG1_OPTD | O/V_ST1 | Y | |
| 19 | OVER VOLTAGE STAGE-2 OPERATED | O/V_STG2_OPTD | O/V_ST2 | Y | |
| 20 | MAIN/TIE CB POLE DISCREPANCY | M/T_CB_POLE_DISC | M/T_PLDSC | N | |
| 21 | CARRIER AIDED TRIP | CAR_AID_TRP | CAR_TRP | Y | |
| 22 | MAIN-1 VT FUSE FAIL | VT_FUS_FAIL_M1 | VT_FF_M1 | N | MAIN-1 |
| 23 | MAIN-2 VT FUSE FAIL | VT_FUS_FAIL_M2 | VT_FF_M2 | N | |
| 24 | MAIN-2 CARRIER RECEIVE | MAIN2_CARR_REC | M2_CR_RC | N | |
| 25 | OPTIONAL | | | | |
| 26 | OPTIONAL | | | | |
| 27 | OPTIONAL | | | | |
| 28 | OPTIONAL | | | | |
| 29 | OPTIONAL | | | | |
| 30 | OPTIONAL | | | | |
| 31 | OPTIONAL | | | | |
| 32 | OPTIONAL | | | | |

| | MAIN-1/2 | | | |
|---|---|---|---|---|
| Configuration of Digital Channels for 16 channels | | | | |
| S.No. | DIGITAL CHANNELS | (Limited to 16 Characters) | 7 characters | Triggers |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y |
| 4 | TIE CB R-PHASE OPEN | TIE_CB_R_OPEN | T CB_RO | Y |
| 5 | TIE CB Y-PHASE OPEN | TIE_CB_Y_OPEN | T CB_YO | Y |

| | | | | |
|---|---|---|---|---|
| 6 | TIE CB B-PHASE OPEN | TIE_CB_B_OPEN | T CB_BO | Y |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y |
| 9 | AUTO RECLOSE OPTD M/T CB | M/T_CB_A/R_OPTD | M/TCBAR | Y |
| 10 | MAIN1/2 CARRIER RECEIVE | MAIN1/2_CARR_REC | M1/2_CR | N |
| 11 | MAIN 1/2 DEF OPTD | DEF_OPD | DEF_OPD | Y |
| 12 | DT RECEIVE CHANNEL-1/2 | DT_REC_CH-1/2 | DTRC1/2 | Y |
| 13 | OVER VOLTAGE STAGE-1/2 OPERATED | O/V_STG1/2_OPTD | OVST1/2 | Y |
| 14 | STUB/TEED/SOTF OPERATED | ST_TEE_SOTF_OPTD | STF_OPD | Y |
| 15 | BUSBAR OPERATED (M1/M2) | BUSBAR_OPTD | BB_OPD | Y |
| 16 | MAIN/TIE CB LBB OPERATED | M/T_LBB_OPTD | M/T_LBB | Y |

**2. DR for Transmission Line (Double Bus cum Transfer)**

**Main 1**

| **A** | **Configuration of ANALOG CHANNELS** | |
|---|---|---|
| **S.No.** | **Channel Description** | **Standardized Channel Name** |
| 1 | R Phase Current | I-R PH. |
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH |
| 5 | R Phase Voltage | V-R PH. |
| 6 | Y Phase Voltage | V-Y PH. |
| 7 | B Phase Voltage | V-B PH. |
| 8 | Open Delta Voltage | V-N-Open Delta |

| **B** | **Configuration of Digital Channels for 32 channels** | | | | |
|---|---|---|---|---|---|
| **S.No.** | **Channel Description** | **(Limited to 16 Characters)** | **7 characters** | **Triggers** | **COMMENTS** |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y | |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y | |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y | |
| 4 | TBC CB R-PHASE OPEN | TBC_CB_R_OPEN | T CB_RO | Y | |
| 5 | TBC CB Y-PHASE OPEN | TBC_CB_Y_OPEN | T CB_YO | Y | |
| 6 | TBC CB B-PHASE OPEN | TBC_CB_B_OPEN | T CB_BO | Y | |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y | |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y | MAIN-2 |
| 9 | AUTO RECLOSE OPTD MAIN CB | MAIN_CB_A/R_OPTD | M CB_AR | Y | |
| 10 | MAIN CB AR LOCKOUT | MAIN CB AR LO | MCB AR LO | N | |

| | | | | | |
|---|---|---|---|---|---|
| 11 | AUTO RECLOSE OPTD TBC CB | TBC_CB_A/R_OPTD | T CB_AR | Y | |
| 12 | TBC CB AR LOCKOUT | TBC_CB_A/R_LO | AR_L/O | N | |
| 13 | MAIN1/2 CARRIER RECEIVE | MAIN1/2_CARR_REC | M1/2_CR | N | MAIN-1/2 |
| 14 | DT RECEIVE CHANNEL-1/2 | DT_REC_CH1/2 | DTRC1/2 | Y | |
| 15 | 3 PH. GROUP A/B OPERATED | 3PH_GR_A/B_OPTD | GRA/B_OPD | Y | |
| 16 | OVER VOLTAGE STAGE-1 OPERATED | O/V_STG1_OPTD | O/V_ST1 | Y | |
| 17 | OVER VOLTAGE STAGE-2 OPERATED | O/V_STG2_OPTD | O/V_ST2 | Y | |
| 18 | POWER SWING BLOCK OPERATED | PS BLK OPTD | PSB_OP | N | |
| 19 | MAIN-1 VT FUSE FAIL | VT_FUS_FAIL_M1 | VT_FF_M1 | N | |
| 20 | BUSBAR OPERATED (M1/M2) | BUSBAR_OPTD | BB_OPD | Y | |
| 21 | MAIN/TBC LBB OPERATED | M/T_LBB_OPTD | M/T_LBB | Y | |
| 22 | MAIN 1 ZONE-1 OPTD. | MAIN1_Z1_OPTD | M1Z1_OP | Y | |
| 23 | MAIN 1 ZONE-2 START | MAIN1_Z2_START | M1Z2_ST | N | |
| 24 | MAIN 1 ZONE-2 OPTD. | MAIN1_Z2_OPTD | M1Z2_OP | Y | |
| 25 | MAIN 1 ZONE-3 START | MAIN1_Z3_START | M1Z3_ST | N | |
| 26 | MAIN 1 ZONE-3 OPTD. | MAIN1_Z3_OPTD | M1Z3_OP | Y | |
| 27 | MAIN 1 REVERSE ZONE OPTD | MAIN1_ZR_OPTD | M1ZR_OP | Y | |
| 28 | MAIN 1/2 SOTF OPTD | M1/2_SOTF_OPD | M12SOTF | Y | |
| 29 | MAIN 1/2 DEF OPTD | DEF_OPD | DEF_OPD | Y | MAIN-1/2 |
| 30 | MAIN1/2 CARR. SEND | M1/2 CARR. SEND | M12CRSD | N | MAIN-1/2 |
| 31 | DIRECT TRIP SEND | DIR_TR SEND | DT_SEND | Y | |
| 32 | CARRIER AIDED TRIP | CARR_AID_TRIP | CAR_AID | Y | |

| | **MAIN-2** | |
|---|---|---|
| **A** | **Configuration of ANALOG CHANNELS** | |
| **S.No.** | **Channel Description** | **Standardized Channel Name** |
| **1** | R Phase Current | I-R PH. |
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH. |
| 5 | R Phase Voltage | V-R PH. |
| 6 | Y Phase Voltage | V-Y PH. |
| 7 | B Phase Voltage | V-B PH. |
| 8 | Open Delta Voltage | V-N (Open Delta) |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y | |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y | |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y | |
| 4 | TBC CB R-PHASE OPEN | TBC_CB_R_OPEN | T CB_RO | Y | |
| 5 | TBC CB Y-PHASE OPEN | TBC_CB_Y_OPEN | T CB_YO | Y | |
| 6 | TBC CB B-PHASE OPEN | TIE_CB_B_OPEN | T CB_BO | Y | |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y | MAIN-1 |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y | |
| 9 | MAIN 2 ZONE-1 OPTD. | MAIN2_Z1_OPTD | M2Z1_OP | Y | |
| 10 | MAIN 2 ZONE-2 START | MAIN2_Z2_START | M2Z2_ST | N | |
| 11 | MAIN 2 ZONE-2 OPTD. | MAIN2_Z2_OPTD | M2Z2_OP | Y | |
| 12 | MAIN 2 ZONE-3 START | MAIN2_Z3_START | M2Z3_ST | N | |
| 13 | MAIN 2 ZONE-3 OPTD. | MAIN2_Z3_OPTD | M2Z3_OP | Y | |
| 14 | MAIN 2 REVERSE ZONE START | MAIN2_ZR_START | M2ZR_ST | N | |
| 15 | MAIN 2 REVERSE ZONE OPTD | MAIN2_ZR_OPTD | M2ZR_OP | Y | |
| 16 | POWER SWING DET. | PS_DETECTED | PS_DET | N | |
| 17 | POWER SWING BLOCK OPERATED | PS BLK OPTD | PSB_OP | N | |
| 18 | OVER VOLTAGE STAGE-1 OPERATED | O/V_STG1_OPTD | O/V_ST1 | Y | |
| 19 | OVER VOLTAGE STAGE-2 OPERATED | O/V_STG2_OPTD | O/V_ST2 | Y | |
| 20 | MAIN/TBC CB POLE DISCREPANCY | M/T_CB_POLE_DISC | M/T_PLDSC | N | |
| 21 | CARRIER AIDED TRIP | CAR_AID_TRP | CAR_TRP | Y | |
| 22 | DIRECT TRIP SEND | DIR_TR SEND | DT_SEND | Y | |
| 23 | MAIN-2 VT FUSE FAIL | VT_FUS_FAIL_M2 | VT_FF_M2 | N | |
| 24 | MAIN-2 CARRIER RECEIVE | MAIN2_CARR_REC | M2_CR_RC | N | |
| 25 | OPTIONAL | | | | |
| 26 | OPTIONAL | | | | |
| 27 | OPTIONAL | | | | |
| 28 | OPTIONAL | | | | |
| 29 | OPTIONAL | | | | |
| 30 | OPTIONAL | | | | |
| 31 | OPTIONAL | | | | |
| 32 | OPTIONAL | | | | |

| Configuration of Digital Channels for 16 channels | | | | |
|---|---|---|---|---|
| S.No. | DIGITAL CHANNELS | (Limited to 16 Characters) | 7 characters | Triggers |

| | | | | |
|---|---|---|---|---|
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y |
| 4 | TBC CB R-PHASE OPEN | TBC_CB_R_OPEN | T CB_RO | Y |
| 5 | TBC CB Y-PHASE OPEN | TBC_CB_Y_OPEN | T CB_YO | Y |
| 6 | TBC CB B-PHASE OPEN | TBC_CB_B_OPEN | T CB_BO | Y |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y |
| 9 | AUTO RECLOSE OPTD M/T CB | M/T_CB_A/R_OPTD | M/TCBAR | Y |
| 10 | MAIN1/2 CARRIER RECEIVE | MAIN1/2_CARR_REC | M1/2_CR | N |
| 11 | MAIN 1/2 DEF OPTD | DEF_OPD | DEF_OPD | Y |
| 12 | DT RECEIVE CHANNEL-1/2 | DT_REC_CH-1/2 | DTRC1/2 | Y |
| 13 | OVER VOLTAGE STAGE-1/2 OPERATED | O/V_STG1/2_OPTD | OVST1/2 | Y |
| 14 | SOTF OPERATED | SOTF_OPTD | STF_OPD | Y |
| 15 | BUSBAR OPERATED (M1/M2) | BUSBAR_OPTD | BB_OPD | Y |
| 16 | MAIN/TBC CB LBB OPERATED | M/T_LBB_OPTD | M/T_LBB | Y |

3. DR for Transformer (one and half breaker scheme)

| **A** | **Configuration of ANALOG CHANNELS** | | |
|---|---|---|---|
| **S.No.** | **Channel Description** | **Standardized Channel Name** | **COMMENTS** |
| 1 | HV R Phase Current | I-R PH. HV | |
| 2 | HV Y Phase Current | I-Y PH. HV | |
| 3 | HV B Phase Current | I-B PH. HV | |
| 4 | HV Neutral Current | I-N HV | |
| 5 | IV R Phase Current | I-R PH. IV | |
| 6 | IV Y Phase Current | I-Y PH. IV | |
| 7 | IV B Phase Current | I-B PH. IV | |
| 9 | IV Neutral Current | I-N IV | |
| 10 | R Phase DIFFERENTIAL Current (CALCULATED) | IR DIFF | |
| 11 | Y Phase DIFFERENTIAL Current (CALCULATED) | IY DIFF | |
| 12 | B Phase DIFFERENTIAL Current (CALCULATED) | IB DIFF | |
| 13 | LV R Phase Current | L-R PH. IV | OPTIONAL |
| 14 | LV Y Phase Current | L-Y PH. IV | OPTIONAL |
| 15 | LV B Phase Current | L-B PH. IV | OPTIONAL |
| 16 | LV Neutral Current | L-N IV | OPTIONAL |
| 17 | HV R Ph Voltage | V-R PH HV | OPTIONAL |
| 18 | HV Y Ph Voltage | V-Y PH HV | OPTIONAL |
| 19 | HV B Ph Voltage | V-B PH HV | OPTIONAL |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 1 | MAIN CB OPEN (HV SIDE) | HV_M_CB_OPEN | HV_MCBO | Y | |
| 2 | TIE CB OPEN (HV SIDE) | HV_T_CB_OPEN | HV_TCBO | Y | |
| 3 | MAIN CB OPEN (IV SIDE) | IV_M_CB_OPEN | IV_MCBO | Y | |
| 4 | TIE/TBC CB OPEN (IV SIDE) | IV_T_CB_OPEN | IV_TCBO | Y | |
| 5 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y | |
| 6 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y | |
| 7 | HV OC PROTECTION OPERATED | HV_B/U_PROTN_OPD | HVBUOPD | Y | |
| 8 | HV EF PROTN OPERATED | HV_EF_PROTN_OPD | HVEFOPD | Y | |
| 9 | HV OVER FLUXING OPERATED | HV_OVERFLUX_OPTD | HVOFOPD | Y | |
| 10 | IV OVER FLUXING OPERATED | IV_OVERFLUX_OPTD | IVOFOPD | Y | |
| 11 | PRV TRIP | PRV_TRIP | PRV_TRP | Y | |
| 12 | WTI TRIP | WTI_TRIP | WTI_TR | Y | HV/IV/LV |
| 13 | OSR TRIP | OSR_TRIP | OSR_TRP | Y | |
| 14 | OTI TRIP | OTI_TRIP | OTI_TRP | Y | |
| 15 | BUCHHOLZ TRIP | BUCHHOLZ_TRIP | BCZ_TRP | Y | |
| 16 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y | |
| 17 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y | |
| 18 | MAIN CB (HV SIDE) LBB OPTD. | HV_MAIN_LBB_OPTD | H_M_LBB | Y | |
| 19 | MAIN CB (IV SIDE) LBB OPTD. | IV_MAIN_LBB_OPTD | I_M_LBB | Y | |
| 20 | TIE CB (HV SIDE) LBB OPTD. | HV_TIE_LBB_OPTD | H_T_LBB | Y | |
| 21 | TIE/TBC CB (IV SIDE) LBB OPTD. | IV_T_LBB_OPTD | I_T_LBB | Y | |
| 22 | BUSBAR OPERATED | BUSBAR_OPTD | BB_OPD | Y | |
| 23 | DTOC OPTD | DTOC_OPTD | DTOCOPD | Y | IF APPLICABLE |
| 24 | OLTC OIL SURGE TRIP | OLTC_OIL SGTR | OL_SR_TR | Y | |
| 25 | HV VT FUSE FAIL ALARM | HVVT_FUS_FAIL | HVVT_FF | N | |
| 26 | WTI ALARM | WTI_ALARM | WTI_AL | N | HV/IV/LV |
| 27 | OTI ALARM | OTI_ALARM | OTI_AL | N | |
| 28 | OVER LOAD ALARM | OL_ALARM | OL_AL | N | |
| 29 | | | | | OPTIONAL |
| 30 | | | | | OPTIONAL |
| 31 | | | | | OPTIONAL |
| 32 | | | | | OPTIONAL |

| Configuration of Digital Channels for 16 channels | | | | |
|---|---|---|---|---|
| S.No. | DIGITAL CHANNELS | (Limited to 16 Characters) | 7 characters | Triggers |

| | | | | |
|---|---|---|---|---|
| 1 | MAIN CB OPEN (HV SIDE) | HV_M_CB_OPEN | HV_MCBO | Y |
| 2 | TIE CB OPEN (HV SIDE) | HV_T_CB_OPEN | HV_TCBO | Y |
| 3 | MAIN CB OPEN (IV SIDE) | IV_M_CB_OPEN | IV_MCBO | Y |
| 4 | TBC/TIE CB OPEN (IV SIDE) | IV_T_CB_OPEN | IV_TCBO | Y |
| 5 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 6 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |
| 7 | HV BACKUP PROTECTION OPERATED | HV_B/U_PROTN_OPD | HVBUOPD | Y |
| 8 | HV/IV OVER FLUXING OPERATED | HV/IV_O/F_OPD | O/F_OPD | Y |
| 9 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 10 | OTI/WTI TRIP | OTI/WTI_TRIP | OT/WT_T | Y |
| 11 | BUCHHOLZ/OSR TRIP | BUCH/OSR_TRIP | B_OSR_T | Y |
| 12 | MAIN/TIE CB (HV SIDE) LBB OPTD. | M/T_HV_LBB | HV_LBB | Y |
| 13 | MAIN/TBC CB (IV SIDE) LBB OPTD. | M/T_IV_LBB | IV_LBB | Y |
| 14 | BUSBAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 15 | DTOC OPTD | DTOC_OPTD | DTOCOPD | Y |
| 16 | 3 PH. GROUP A/B OPERATED | 3PH_GR_A/B_OPTD | GRA/B_OPD | Y |

**4. DR for Bus/Line Reactor for one and half breaker scheme**

a. For back up Impedance Relay

| **A** | **Configuration of ANALOG CHANNELS** | | |
|---|---|---|---|
| S.No. | Channel Description | Standardized Channel Name | COMMENTS |
| 1 | R Phase Current | I-R PH. | |
| 2 | Y Phase Current | I-Y PH. | |
| 3 | B Phase Current | I-B PH. | |
| 4 | Neutral Current | I-N PH. | |
| 5 | R Phase Voltage | V-R PH. | |
| 6 | Y Phase Voltage | V-Y PH. | |
| 7 | B Phase Voltage | V-B PH. | |
| 8 | Neutral voltage | V-N PH. | |

| **B** | **Configuration of Digital Channels for 32 channels** | | | |
|---|---|---|---|---|
| **S.No.** | **Channel Description** | **(Limited to 16 Characters)** | **7 characters** | **Triggers** |
| 1 | MAIN CB OPEN | MAIN_CB_OPEN | M_CB_O | Y |
| 2 | TIE CB OPEN | TIE_CB_OPEN | T_CB_O | Y |
| 3 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 4 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |

| | | | | |
|---|---|---|---|---|
| 5 | BACKUP IMPEDANCE PROTN OPERATED | BU_IMP_PROTN_OPD | BUIMPOP | Y |
| 6 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 7 | WTI TRIP | WTI_TRIP | WTI_TRP | Y |
| 8 | WTI ALARM | WTI_ALARM | WTI_AL | Y |
| 9 | OTI TRIP | OTI_TRIP | OTI_TRP | Y |
| 10 | OTI ALARM | OTI_ALARM | OTI_AL | Y |
| 11 | BUCHHHOLZ TRIP | BUCHHHOLZ_TRIP | BCZ_TRP | Y |
| 12 | BUCHHHOLZ ALARM | BUCHHHOLZ_ALARM | BCZ_AL | Y |
| 13 | MAIN LBB OPERATED | MAIN_LBB_OPD | MLBBOPD | Y |
| 14 | TIE LBB OPERATED | TIE_LBB_OPD | TLBBOPD | Y |
| 15 | BUS BAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 16 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y |
| 17 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y |
| 18 | NGR PROTECTION OPERATED | NGR_PROTN_OPTD | NGR_OPD | Y |
| 19 | TEED PROTECTION OPERATED | TEED_PROTN_OPTD | TEE_OPD | Y |
| 20 | VT FUSE FAIL ALARM | VT_FUS_FAIL | VT_FF | N |

| **B** | **Configuration of Digital Channels for 16 channels** | | | |
|---|---|---|---|---|
| **S.No.** | **Channel Description** | **(Limited to 16 Characters)** | **7 characters** | **Triggers** |
| 1 | MAIN CB OPEN | MAIN_CB_OPEN | M_CB_O | Y |
| 2 | TIE CB OPEN | TIE_CB_OPEN | T_CB_O | Y |
| 3 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 4 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |
| 5 | BACKUP IMPEDANCE PROTN OPERATED | BU_IMP_PROTN_OPD | BUIMPOP | Y |
| 6 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 7 | WTI TRIP | WTI_TRIP | WTI_TRP | Y |
| 8 | TEED PROTECTION OPERATED | TEED_PROTN_OPTD | TEE_OPD | Y |
| 9 | OTI TRIP | OTI_TRIP | OTI_TRP | Y |
| 10 | BUCHHHOLZ TRIP | BUCHHHOLZ_TRIP | BCZ_TRP | Y |
| 11 | MAIN LBB OPERATED | MAIN_LBB_OPD | MLBBOPD | Y |
| 12 | TIE LBB OPERATED | TIE_LBB_OPD | TLBBOPD | Y |
| 13 | BUS BAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 14 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y |
| 15 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y |
| 16 | NGR PROTECTION OPERATED | NGR_PROTN_OPTD | NGR_OPD | Y |

b. For Main Differential Relay

| A | Configuration of ANALOG CHANNELS | |
|---|---|---|
| S.No. | Channel Description | Standardized Channel Name |
| 1 | R Phase Current | I-R PH. |
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH. |
| 5 | R Phase Current NEUTRAL SIDE | I-RN PH. |
| 6 | Y Phase Current NEUTRAL SIDE | I-YN PH. |
| 7 | B Phase Current NEUTRAL SIDE | I-BN PH. |
| 8 | R Phase DIFFERENTIAL Current (CALCULATED) | IR DIFF |
| 9 | Y Phase DIFFERENTIAL Current (CALCULATED) | IY DIFF |
| 10 | B Phase DIFFERENTIAL Current (CALCULATED) | IB DIFF |

| B | Configuration of Digital Channels for 32 channels | | | |
|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers |
| 1 | MAIN CB OPEN | MAIN_CB_OPEN | M_CB_O | Y |
| 2 | TIE CB OPEN | TIE_CB_OPEN | T_CB_O | Y |
| 3 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 4 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |
| 5 | BACKUP IMPEDANCE PROTN OPERATED | BU_IMP_PROTN_OPD | BUIMPOP | Y |
| 6 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 7 | WTI TRIP | WTI_TRIP | WTI_TRP | Y |
| 8 | WTI ALARM | WTI_ALARM | WTI_AL | Y |
| 9 | OTI TRIP | OTI_TRIP | OTI_TRP | Y |
| 10 | OTI ALARM | OTI_ALARM | OTI_AL | Y |
| 11 | BUCHHHOLZ TRIP | BUCHHHOLZ_TRIP | BCZ_TRP | Y |
| 12 | BUCHHHOLZ ALARM | BUCHHHOLZ_ALARM | BCZ_AL | Y |
| 13 | MAIN LBB OPERATED | MAIN_LBB_OPD | MLBBOPD | Y |
| 14 | TIE LBB OPERATED | TIE_LBB_OPD | TLBBOPD | Y |
| 15 | BUS BAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 16 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y |
| 17 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y |
| 18 | NGR PROTECTION OPERATED | NGR_PROTN_OPTD | NGR_OPD | Y |
| 19 | TEED PROTECTION OPERATED | TEED_PROTN_OPTD | TEE_OPD | Y |

| B | Configuration of Digital Channels for 16 channels |
|---|---|

| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers |
|---|---|---|---|---|
| 1 | MAIN CB OPEN | MAIN_CB_OPEN | M_CB_O | Y |
| 2 | TIE CB OPEN | TIE_CB_OPEN | T_CB_O | Y |
| 3 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 4 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |
| 5 | BACKUP IMPEDANCE PROTN OPERATED | BU_IMP_PROTN_OPD | BUIMPOP | Y |
| 6 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 7 | WTI TRIP | WTI_TRIP | WTI_TRP | Y |
| 8 | TEED PROTECTION OPERATED | TEED_PROTN_OPTD | TEE_OPD | Y |
| 9 | OTI TRIP | OTI_TRIP | OTI_TRP | Y |
| 10 | BUCHHHOLZ TRIP | BUCHHHOLZ_TRIP | BCZ_TRP | Y |
| 11 | MAIN LBB OPERATED | MAIN_LBB_OPD | MLBBOPD | Y |
| 12 | TIE LBB OPERATED | TIE_LBB_OPD | TLBBOPD | Y |
| 13 | BUS BAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 14 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y |
| 15 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y |
| 16 | NGR PROTECTION OPERATED | NGR_PROTN_OPTD | NGR_OPD | Y |

**5. Standard list of Sequence of Events (SOE)**

**SCADA SIGNAL LIST FOR VARIOUS PROTECTION & CONTROL SIGNALS**

| REQUIRED SIGNALS FOR DISTANCE RELAYS | | | |
|---|---|---|---|
| **SL. NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 1 | SPI | OVERVOLATGE STAGE 1 START | |
| 2 | SPI | OVERVOLATGE STAGE 1 GEN TRIP | Y |
| 3 | SPI | OVERVOLATGE STAGE 2 GEN TRIP | Y |
| 4 | SPI | DEF START | |
| 5 | SPI | DEF GEN TRIP | Y |
| 6 | SPI | STUB PROTECTION OPERATED | Y |
| 7 | SPI | SOTF OPERATED | Y |
| 8 | SPI | START, Z1 R PH | |
| 9 | SPI | START, Z1 Y PH | |
| 10 | SPI | START, Z1 B PH | |

| | | | |
|---|---|---|---|
| 11 | SPI | START, Z2 | |
| 12 | SPI | START, Z3 | |
| 13 | SPI | START, Z4 | |
| 14 | SPI | START, Z5 | |
| 15 | SPI | TRIP, Z1 R PH | Y |
| 16 | SPI | TRIP, Z1 Y PH | Y |
| 17 | SPI | TRIP, Z1 B PH | Y |
| 18 | SPI | GENERAL TRIP, Z2 | Y |
| 19 | SPI | GENERAL TRIP, Z3 | Y |
| 20 | SPI | GENERAL TRIP, Z4 | Y |
| 21 | SPI | GENERAL TRIP, Z5 | Y |
| 22 | SPI | CARRIER SEND | Y |
| 23 | SPI | CARRIER RECEIVE | Y |
| 24 | SPI | CARRIER AIDED SCHEME OPERATED | Y |
| 25 | SPI | POWER SWING DETECTED | Y |
| 26 | SPI | POWER SWING BLOCKING | Y |
| 27 | SPI | DISTANCE RELAY GENERAL TRIP | Y |
| 28 | DINT | FAULT LOCATOR DISTANCE | |
| 29 | SPI | CVT FUSE FAIL | Y |
| 30 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 31 | System Diagnosis (SON) | M1 IED UNHEALTHY | Y |
| 32 | SPI | START AR | |
| 33 | SPI | LINE ISOLATOR OPEN FOR STUB ACTIVATION | |
| 34 | SPI | DT SEND CH 1 | Y |
| 35 | SPI | DT SEND CH 1 | Y |
| 36 | SPI | DT RECEIVE CH 1 | Y |
| 37 | SPI | DT RECEIVE CH 2 | Y |
| 38 | SPI | MAIN CB R PH OPEN | |
| 39 | SPI | MAIN CB Y PH OPEN | |
| 40 | SPI | MAIN CB B PH OPEN | |
| 41 | SPI | TIE CB R PH OPEN | |
| 42 | SPI | TIE CB Y PH OPEN | |
| 43 | SPI | TIE CB B PH OPEN | |
| 44 | SPI | TRIP RELAY 86 A HEALTHY (SUPERVISION) | |
| 45 | SPI | TRIP RELAY 86 B HEALTHY (SUPERVISION) | |
| 46 | SPI | GR A RELAY OPERATED | Y |
| 47 | SPI | GR B RELAY OPERATED | Y |

| | | | |
|---|---|---|---|
| 48 | SPI | CARRIER CHANNEL 1/2 OUT OF SERVICE | Y |
| 49 | SPI | CARRIER CHANNEL 1 FAIL | Y |
| 50 | SPI | CARRIER CHANNEL 2 FAIL | Y |
| 51 | SPI | MAIN 2/1 RELAY FAIL | Y |
| 52 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 53 | | **ANY ADDITIONAL SIGNAL AS PER SCHEME** | |

| **REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS** | | | |
|---|---|---|---|
| **SL. NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 1 | SPI | OVEREXCITATION HV START | |
| 2 | SPI | OVEREXCITATION HV ALARM | Y |
| 3 | SPI | OVEREXCITATION HV TRIP | Y |
| 4 | SPI | DIFFERENTIAL CURRENT ALARM | Y |
| 5 | SPI | DIFFERENTIAL PROTECTION TRIP | Y |
| 6 | INT | RESTRAINED MODE (RESTRAINED OR UNRESTRAINED) | |
| 7 | SPI | GENERAL TRIP | Y |
| 8 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 9 | System Diagnosis (SON) | DIFFRENTIAL IED UNHEALTHY | Y |
| 10 | SPI | DIFFERENTIAL RELAY GENERAL TRIP | Y |
| 11 | SPI | OTI ALARM | Y |
| 12 | SPI | WTI HV ALARM | Y |
| 13 | SPI | WTI IV ALARM | Y |
| 14 | SPI | WTI MV ALARM | Y |
| 15 | SPI | BUCCHOLZ TRIP | Y |
| 16 | SPI | OSR 1 TRIP | Y |
| 17 | SPI | PRD 1 TRIP | Y |
| 18 | SPI | FIRE PROTECTION OPERATED | Y |
| 19 | SPI | LOW OIL LEVEL | Y |
| 20 | SPI | OTI R PH ALARM | Y |
| 21 | SPI | OTI Y PH ALARM | Y |

| REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS | | | |
|---|---|---|---|
| **SL. NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 22 | SPI | OTI B PH ALARM | Y |
| 23 | SPI | OTI SPARE ICT ALARM | Y |
| 24 | SPI | WTI HV R PH ALARM | Y |
| 25 | SPI | WTI HV Y PH ALARM | Y |
| 26 | SPI | WTI HV B PH ALARM | Y |
| 27 | SPI | WTI HV SPARE ICT ALARM | Y |
| 28 | SPI | WTI MV R PH ALARM | Y |
| 29 | SPI | WTI MV Y PH ALARM | Y |
| 30 | SPI | WTI MV B PH ALARM | Y |
| 31 | SPI | WTI MV SPARE ICT ALARM | Y |
| 32 | SPI | WTI IV R PH ALARM | Y |
| 33 | SPI | WTI IV Y PH ALARM | Y |
| 34 | SPI | WTI IV B PH ALARM | Y |
| 35 | SPI | WTI IV SPARE ICT ALARM | Y |
| 36 | SPI | BUCCHOLZ R PH TRIP | Y |
| 37 | SPI | BUCCHOLZ Y PH TRIP | Y |
| 38 | SPI | BUCCHOLZ B PH TRIP | Y |
| 39 | SPI | BUCCHOLZ SPARE ICT TRIP | Y |
| 40 | SPI | OSR 1 R PH TRIP | Y |
| 41 | SPI | OSR 1 Y PH TRIP | Y |
| 42 | SPI | OSR 1 B PH TRIP | Y |
| 43 | SPI | OSR 1 SPARE ICT TRIP | Y |
| 44 | SPI | PRD 1 R PH TRIP | Y |
| 45 | SPI | PRD 1 Y PH TRIP | Y |
| 46 | SPI | PRD 1 B PH TRIP | Y |
| 47 | SPI | LOW OIL LEVEL R PH | Y |
| 48 | SPI | LOW OIL LEVEL Y PH | Y |
| 49 | SPI | LOW OIL LEVEL B PH | Y |
| 50 | SPI | LOW OIL LEVEL SPARE ICT | Y |
| 51 | SPI | FIRE PROTECTION R PH OPERATED | Y |
| 52 | SPI | FIRE PROTECTION Y PH OPERATED | Y |
| 53 | SPI | FIRE PROTECTION B PH OPERATED | Y |
| 54 | SPI | FIRE PROTECTION SPARE ICT OPERATED | Y |
| 55 | SPI | MAIN CB R PH OPEN | |
| 56 | SPI | MAIN CB Y PH OPEN | |

| REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS | | | |
|---|---|---|---|
| **SL. NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 57 | SPI | MAIN CB B PH OPEN | |
| 58 | SPI | TIE CB R PH OPEN | |
| 59 | SPI | TIE CB Y PH OPEN | |
| 60 | SPI | TIE CB B PH OPEN | |
| 61 | SPI | TRIP RELAY 86 A HEALTHY (SUPERVISION) | Y |
| 62 | SPI | TRIP RELAY 86 B HEALTHY (SUPERVISION) | Y |
| 63 | SPI | GR A RELAY OPERATED | Y |
| 64 | SPI | GR B RELAY OPERATED | Y |
| 65 | SPI | REF RELAY FAIL | Y |
| 66 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 67 | SPI | **ANY ADDITIONAL SIGNAL AS PER SCHEME** | |

| REQUIRED SIGNALS FOR ICT REF RELAYS | | | |
|---|---|---|---|
| **SL. NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 1 | SPI | OVEREXCITATION MV START | |
| 2 | SPI | OVEREXCITATION MV ALARM | Y |
| 3 | SPI | OVEREXCITATION MV TRIP | Y |
| 4 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 5 | System Diagnosis (SON) | DIFFRENTIAL IED UNHEALTHY | Y |
| 6 | SPI | REF RELAY ALARM | Y |
| 7 | SPI | REF TRIP | Y |
| 8 | SPI | GENERAL TRIP | Y |
| 9 | SPI | REF TRIP | Y |
| 10 | SPI | OTI TRIP | Y |
| 11 | SPI | WTI HV TRIP | Y |
| 12 | SPI | WTI MV TRIP | Y |
| 13 | SPI | WTI LV TRIP | Y |
| 14 | SPI | OSR 2 TRIP | Y |
| 15 | SPI | PRD 2 TRIP | Y |
| 16 | SPI | BUCCHOLZ ALARM | Y |
| 17 | SPI | OTI R PH TRIP | Y |

| REQUIRED SIGNALS FOR ICT REF RELAYS | | | |
|---|---|---|---|
| **SL. NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 18 | SPI | OTI Y PH TRIP | Y |
| 19 | SPI | OTI B PH TRIP | Y |
| 20 | SPI | OTI SPARE ICT TRIP | Y |
| 21 | SPI | WTI HV R PH TRIP | Y |
| 22 | SPI | WTI HV Y PH TRIP | Y |
| 23 | SPI | WTI HV B PH TRIP | Y |
| 24 | SPI | WTI HV SPARE ICT TRIP | Y |
| 25 | SPI | WTI MV R PH TRIP | Y |
| 26 | SPI | WTI MV Y PH TRIP | Y |
| 27 | SPI | WTI MV B PH TRIP | Y |
| 28 | SPI | WTI MV SPARE ICT TRIP | Y |
| 29 | SPI | WTI IV R PH TRIP | Y |
| 30 | SPI | WTI IV Y PH TRIP | Y |
| 31 | SPI | WTI IV B PH TRIP | Y |
| 32 | SPI | WTI IV SPARE ICT TRIP | Y |
| 33 | SPI | BUCCHOLZ R PH ALARM | Y |
| 34 | SPI | BUCCHOLZ Y PH ALARM | Y |
| 35 | SPI | BUCCHOLZ B PH ALARM | Y |
| 36 | SPI | BUCCHOLZ SPARE ICT ALARM | Y |
| 37 | SPI | OSR 2 R PH TRIP | Y |
| 38 | SPI | OSR 2 Y PH TRIP | Y |
| 39 | SPI | OSR 2 B PH TRIP | Y |
| 40 | SPI | OSR 2 SPARE ICT TRIP | Y |
| 41 | SPI | PRD 2 R PH TRIP | Y |
| 42 | SPI | PRD 2 Y PH TRIP | Y |
| 43 | SPI | PRD 2 B PH TRIP | Y |
| 44 | SPI | PRD 2 SPARE ICT TRIP | Y |
| 45 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 46 | | **ANY ADDITIONAL SIGNAL AS PER SCHEME** | |

| REQUIRED SIGNALS FOR DIRECTIONAL OVERCURRENT AND EARTH FAULT RELAYS | | | |
|---|---|---|---|
| **SL. NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 1 | SPI | DEF START | |
| 2 | SPI | DEF GEN TRIP | Y |

| | | | |
|---|---|---|---|
| 3 | SPI | DIRECTIONAL OVERCURRENT START | Y |
| 4 | SPI | DIRECTIONAL OVERCURRENT TRIP | Y |
| 5 | SPI | GENERAL TRIP | Y |
| 6 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 7 | System Diagnosis (SON) | M1 IED UNHEALTHY | Y |
| 8 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 9 | | **ANY ADDITIONAL SIGNAL AS PER SCHEME** | |

| **REQUIRED SIGNALS FOR REACTOR DIFFERENTIAL RELAYS** | | | |
|---|---|---|---|
| **SL.NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 1 | SPI | DIFFERENTIAL PROTECTION TRIP | Y |
| 2 | SPI | DIFFERENTIAL CURRENT ALARM | Y |
| 3 | SPI | TEE DIFFERENTIAL PROTECTION TRIP | Y |
| 4 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 5 | System Diagnosis (SON) | DIFFRENTIAL IED UNHEALTHY | Y |
| 6 | SPI | DIFFERENTIAL RELAY GENERAL TRIP | Y |
| 7 | SPI | OTI ALARM | Y |
| 8 | SPI | WTI ALARM | Y |
| 9 | SPI | BUCCHOLZ TRIP | Y |
| 10 | SPI | OSR TRIP | Y |
| 11 | SPI | PRD TRIP | Y |
| 12 | SPI | FIRE PROTECTION OPERATED | Y |
| 13 | SPI | LOW OIL LEVEL | Y |
| 14 | SPI | OTI R PH ALARM | Y |
| 15 | SPI | OTI Y PH ALARM | Y |

| | | | |
|---|---|---|---|
| 16 | SPI | OTI B PH ALARM | Y |
| 17 | SPI | OTI SPARE PH ALARM | Y |
| 18 | SPI | WTI R PH ALARM | Y |
| 19 | SPI | WTI Y PH ALARM | Y |
| 20 | SPI | WTI B PH ALARM | Y |
| 21 | SPI | WTI SPARE ICT ALARM | Y |
| 22 | SPI | BUCCHOLZ R PH TRIP | Y |
| 23 | SPI | BUCCHOLZ Y PH TRIP | Y |
| 24 | SPI | BUCCHOLZ B PH TRIP | Y |
| 25 | SPI | BUCCHOLZ SPARE PH TRIP | Y |
| 26 | SPI | OSR R PH TRIP | Y |
| 27 | SPI | OSR Y PH TRIP | Y |
| 28 | SPI | OSR B PH TRIP | Y |
| 29 | SPI | OSR SPARE ICT TRIP | Y |
| 30 | SPI | PRD R PH TRIP | Y |
| 31 | SPI | PRD Y PH TRIP | Y |
| 32 | SPI | PRD B PH TRIP | Y |
| 33 | SPI | LOW OIL LEVEL R PH | Y |
| 34 | SPI | LOW OIL LEVEL Y PH | Y |
| 35 | SPI | LOW OIL LEVEL B PH | Y |
| 36 | SPI | LOW OIL LEVEL SPARE ICT | Y |
| 37 | SPI | FIRE PROTECTION R PH OPERATED | Y |
| 38 | SPI | FIRE PROTECTION Y PH OPERATED | Y |
| 39 | SPI | FIRE PROTECTION B PH OPERATED | Y |
| 40 | SPI | FIRE PROTECTION SPARE ICT OPERATED | Y |
| 41 | SPI | MAIN CB R PH OPEN | Y |
| 42 | SPI | MAIN CB Y PH OPEN | Y |
| 43 | SPI | MAIN CB B PH OPEN | Y |
| 44 | SPI | TIE CB R PH OPEN | Y |
| | | | |
| 45 | SPI | TIE CB Y PH OPEN | Y |
| 46 | SPI | TIE CB B PH OPEN | Y |
| | | | |
| 47 | SPI | TRIP RELAY 86 A HEALTHY (SUPERVISION) | Y |
| 48 | SPI | TRIP RELAY 86 B HEALTHY (SUPERVISION) | Y |
| 49 | SPI | GR A RELAY OPERATED | Y |
| 50 | SPI | GR B RELAY OPERATED | Y |
| 51 | SPI | REF RELAY FAIL | Y |

| | | | |
|---|---|---|---|
| 52 | SPI | REACTOR CB R PH OPEN | APPLICABLE FOR SWITCHABLE REACTOR APPLICATION |
| 53 | SPI | REACTOR CB Y PH OPEN | |
| 54 | SPI | REACTOR CB B PH OPEN | |
| 55 | SPI | REACTOR CB SPARE PH OPEN | |
| 56 | SPI | GR A RELAY OPERATED | Y |
| 57 | SPI | GR B RELAY OPERATED | Y |
| 58 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 59 | SPI | **ANY ADDITIONAL SIGNAL AS PER SCHEME** | |

| **REQUIRED SIGNALS FOR REACTOR REF RELAYS** | | | |
|---|---|---|---|
| **SL. NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 1 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 2 | System Diagnosis (SON) | DIFFRENTIAL IED UNHEALTHY | Y |
| 3 | SPI | REF RELAY ALARM | Y |
| 4 | SPI | REF TRIP | Y |
| 5 | SPI | GENERAL TRIP | Y |
| 6 | SPI | REF TRIP | Y |
| 7 | SPI | OTI TRIP | Y |
| 8 | SPI | WTI TRIP | Y |
| 9 | SPI | BUCCHOLZ ALARM | Y |
| 10 | SPI | OTI R PH TRIP | Y |
| 11 | SPI | OTI Y PH TRIP | Y |
| 12 | SPI | OTI B PH TRIP | Y |
| 13 | SPI | OTI SPARE ICT TRIP | Y |
| 14 | SPI | WTI R PH TRIP | Y |
| 15 | SPI | WTI Y PH TRIP | Y |
| 16 | SPI | WTI B PH TRIP | Y |
| 17 | SPI | WTI SPARE PH TRIP | Y |
| 18 | SPI | BUCCHOLZ R PH ALARM | Y |

| | | | |
|---|---|---|---|
| 19 | SPI | BUCCHOLZ Y PH ALARM | Y |
| 20 | SPI | BUCCHOLZ B PH ALARM | Y |
| 21 | SPI | BUCCHOLZ SPARE PH ALARM | Y |
| 22 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 23 | | **ANY ADDITIONAL SIGNAL AS PER SCHEME** | |

| **REQUIRED SIGNALS FOR REACTOR BACKUP IMPEDANCE PROTECTION RELAY** | | | |
|---|---|---|---|
| **SL. NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 1 | SPI | START Z1 | |
| 2 | SPI | Z1 TRIP | Y |
| 3 | SPI | GENERAL TRIP | Y |
| 4 | DINT | FAULT LOCATOR DISTANCE | |
| 5 | SPI | CVT FUSE FAIL | Y |
| 6 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 7 | System Diagnosis (SON) | M1 IED UNHEALTHY | Y |
| 22 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 8 | | **ANY ADDITIONAL SIGNAL AS PER SCHEME** | |

| **REQUIRED SIGNALS FOR BUS BAR PROTECTION RELAYS** | | | |
|---|---|---|---|
| **SL.NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** |
| 1 | SPI | BUS ZONE 1 TRIP | Y |
| 2 | SPI | BUS ZONE 2 TRIP | Y |
| 3 | SPI | BUS BAR BLOCKED EXTERNAL | Y |
| 4 | SPI | BUS BAR BLOCKED DUE TO COMMUNICATIONN ERROR | Y |
| 5 | SPI | BUS BAR BLOCKED DUE TO INTERMEDIATE STATUS | Y |
| 6 | | CT CIRCUIT ERROR | Y |

| **REQUIRED SIGNALS FOR BREAKER FAILURE PROTECTION RELAY PROTECTION RELAY** |
|---|

| SL. NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |
|---|---|---|---|
| 1 | SPI | BREAKER FAILURE PROTECTION START | Y |
| 2 | SPI | BREAKER FAILURE TRIP | Y |
| 3 | SPI | BREAKER FAILURE RETRIP | Y |
| 4 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 5 | System Diagnosis (SON) | M1 IED UNHEALTHY | Y |
| 6 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 7 | | | |
| 8 | | **ANY ADDITIONAL SIGNAL AS PER SCHEME** | |

| **REQUIRED SIGNALS FOR BAY CONTROL UNIT** | | | | |
|---|---|---|---|---|
| **SL.NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** | **ADDITIONAL REMARKS** |
| 1 | INT | BCU IN LOCAL/ REMOTE | | |
| 2 | SPI | CLOSE COMMAND FROM BCU FOR AUTORECLOSE | | |
| 3 | SPI | BLOCK AUTORECLOSE FUNCTION | Y | |
| 4 | **INT** | **STATUS 1 AUTORECLOSE FUNCTION READY** | | |
| | | **STATUS 2 AUTORECLOSE IN PROGRESS** | **Y** | |
| | | **STATUS 3 AUTORECLOSE SUCCESSFUL** | **Y** | |
| | | **STATUS 10 AUTORECLOSE UNSUCCESSFUL** | **Y** | Available in Edition 2 IEDs, not in Edition 1 IEDs |
| 5 | CMD | BAY_CB_COMMAND | | |
| 6 | SPI | BAY_CB_OPEN PERMITTED OR ENABLED | | |

| REQUIRED SIGNALS FOR BAY CONTROL UNIT | | | | |
|---|---|---|---|---|
| **SL.NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** | **ADDITIONAL REMARKS** |
| 7 | SPI | BAY_CB_CLOSE PERMITTED OR ENABLED | | |
| 8 | DPI | BAY_CB R PH POSITION | | |
| 9 | DPI | BAY_CB Y PH POSITION | | |
| 10 | DPI | BAY_CB B PH POSITION | | |
| 11 | DPI | BAY_89A_ISOLATOR POSITION | | |
| 12 | CMD | BAY_89A_ISO COMMAND | | |
| 13 | SPI | BAY_89A_ISO OPEN PERMITTED OR ENABLED | | |
| 14 | SPI | BAY 89A_CLOSE PERMITTED OR ENABLED | | |
| 15 | DPI | BAY_89AE_ISOLATOR POSITION | | IF BUS EARTH SWITCH IS IN THE BAY FOR WHICH THE ASSIGNMENT IS BEING DONE, CSWI3 SHALL BE USED FOR 89 AE 1, i.e. BUS EARTH SWITCH. FOR BAY SIDE EARTH SWITCH (89AE2) SEPARATE LOGICAL NODE CSWI 10 IS PROVIDED BELOW |
| 16 | CMD | BAY_89AE_ISO COMMAND | | |
| 17 | SPI | BAY_89AE_ISO OPEN PERMITTED OR ENABLED | | |
| 18 | SPI | BAY_89AE_CLOSE PERMITTED OR ENABLED | | |
| 19 | DPI | BAY_89 B_ISOLATOR POSITION | | |
| 20 | CMD | BAY_89 B_ISO COMMAND | | |
| 21 | SPI | BAY_89 B_ISO OPEN PERMITTED OR ENABLED | | |
| 22 | SPI | BAY_89 B_CLOSE PERMITTED OR ENABLED | | |
| 23 | DPI | BAY_89 BE_ISOLATOR POSITION | | |
| 24 | CMD | BAY_89 BE_ISO COMMAND | | |
| 25 | SPI | BAY_89 BE_ISO OPEN PERMITTED OR ENABLED | | |
| 26 | SPI | BAY_89 BE_CLOSE PERMITTED OR ENABLED | | |

| REQUIRED SIGNALS FOR BAY CONTROL UNIT | | | | |
|---|---|---|---|---|
| **SL.NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** | **ADDITIONAL REMARKS** |
| 27 | DPI | BAY_89 C/L/T_ISOLATOR POSITION | | FOR 3 PHASE TRANSFORMERS CSWI7 MAY BE USED FOR 89 T BUT FOR SINGLE PHASE TRANSFORMERS SAME HAS BEEN SEPARATELY MENTIONED |
| 28 | CMD | BAY_89 C/L/T_ISO COMMAND | | |
| 29 | SPI | BAY_89 C/L/T_ISO OPEN PERMITTED OR ENABLED | | |
| 30 | SPI | BAY_89 C/L/T_CLOSE PERMITTED OR ENABLED | | |
| 31 | DPI | BAY_89 CE/LE/TE_ISOLATOR POSITION | | FOR 3 PHASE TRANSFORMERS CSWI7 MAY BE USED FOR 89 TE BUT FOR SINGLE PHASE TRANSFORMERS SAME HAS BEEN SEPARATELY MENTIONED |
| 32 | CMD | BAY_89 CE/LE/TE_ISO COMMAND | | |
| 33 | SPI | BAY_89 CE/LE/TE_ISO OPEN PERMITTED OR ENABLED | | |
| 34 | SPI | BAY_89 CE/LE/TE_CLOSE PERMITTED OR ENABLED | | |
| 35 | DPI | BAY_89 R_ISOLATOR POSITION | | |
| 36 | CMD | BAY_89 R_ISO COMMAND | | |
| 37 | SPI | BAY_89 R_ISO OPEN PERMITTED OR ENABLED | | |
| 38 | SPI | BAY_89 R_CLOSE PERMITTED OR ENABLED | | |
| 39 | DPI | BAY_89 RE_ISOLATOR POSITION | | |
| 40 | CMD | BAY_89 RE_ISO COMMAND | | |
| 41 | SPI | BAY_89 RE_ISO OPEN PERMITTED OR ENABLED | | |
| 42 | SPI | BAY_89 RE_CLOSE PERMITTED OR ENABLED | | |
| 43 | DPI | BAY_89AE 2_ISOLATOR POSITION | | USED FOR SECOND EARTH SWITCH OF ISOLATOR, WHEN BUS EARTH SWITCH IS PROVIDED |
| 44 | CMD | BAY_89AE 2_ISO COMMAND | | |
| 45 | SPI | BAY_89AE 2_ISO OPEN PERMITTED OR ENABLED | | |
| 46 | SPI | BAY_89AE 2_CLOSE PERMITTED OR ENABLED | | |
| THE LOGICAL NODES FOR ISOLATOR & EARTHSWITCHES FOR 3 PH ICTs & REACTORS , e.g 89 RR,RR1,RR2 & RE and for 89TR,TR1,TR2,TRE MAY BE ASSIGNED AS PER AVAILABILITY | | | | |

| REQUIRED SIGNALS FOR BAY CONTROL UNIT | | | | |
|---|---|---|---|---|
| **SL.NO.** | **TYPE** | **EVENT/ALARM NAME** | **WHETHER ALARM TO BE GENERATED** | **ADDITIONAL REMARKS** |
| 47 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y | |
| 48 | System Diagnosis (SON) | BCU UNHEALTHY | Y | |
| 49 | SPI | CONDITIONS OK FOR SYNCHRONIZATION | | |
| 50 | SPI | SPRING DISCHARGED | Y | ANNUNCIATION FOR CIRCUIT BREAKER |
| 51 | SPI | AC MOTOR SUPPLY FAIL | Y | |
| 52 | SPI | SF6 GAS LOW | Y | |
| 53 | SPI | OPERATION LOCKED OUT | Y | |
| 54 | SPI | CB READY FOR AUTORECLOSURE | Y | |
| 55 | SPI | DC SUPPLY FAIL | Y | |
| 56 | SPI | TC-1 FAIL | Y | |
| 57 | SPI | TC-2 FAIL | Y | |
| 58 | SPI | POLE DISCREPANCY RELAY OPTD | Y | |
| 59 | SPI | COMPRESSOR SUPPLY FAIL | Y | |
| 60 | SPI | AIR PRESSURE LOW | Y | |
| 61 | SPI | COMPRESSOR RUN TIME SUPERVISION | Y | |
| 62 | SPI | CSD FAIL | Y | |
| 63 | SPI | GAS COMPARTMENT n Alarm Stage n | Y | ANNUNCIATION FOR GIS BAYS |
| 64 | SPI | LCC PANEL AC SUPPLY FAIL | Y | |
| 65 | SPI | LCC PANEL DC SUPPLY FAIL | Y | |
| 66 | SPI | SELECTOR SWITCH POSITION LOCAL/REMOTE | Y | |
| 67 | SPI | BUS VT MCB TRIP | Y | FOR BCUs HAVING BUS VT INPUT |
| 6 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y | |
| 68 | SPI | ADDL SIGNALS FOR CB TROUBLE ETC AS PER SCHEME | | |

**6. List of Signal for Station Auxiliaries Panel (SAS)**

**110V DC**

1. Voltage of 110V DCDB-1
2. Voltage of 110V DCDB-2
3. Current from 110V Battery Set -1

4. Current from 110V Battery Set -2
5. Current from 110V Battery Charger -1
6. Current from110V Battery charger 2
7. Battery 1 Output Voltage
8. Battery 2 Output Voltage
9. Charger Trouble 1
10. Charger Trouble 2
11. Charger 1 on Boost
12. Charger 1 on Float
13. Charger 1 Failure (Float)
14. Charger 1 Failure (FCBC)
15. Charger 2 on Boost
16. Charger 2 on Float
17. Charger 2 Failure (Float)
18. Charger 2 Failure (FCBC)
19. Charger 1 Float Current
20. Charger 1 Boost Current
21. Charger 2 Float Current
22. Charger 2 Boost Current
23. Input MCCB Incomer-1 ON (DCDB)
24. Input MCCB Incomer-2 ON (DCDB)
25. DCDB Bus coupler MCCB OFF
26. DC Earth Fault Relay Operated Sec-I
27. DC Earth Fault Relay Operated Sec-II
28. 415 V AC Supply MCCB-1 Trip
29. 415 V AC Supply MCCB-2 Trip
30. Over Temperature Indication
31. DC Overvoltage and Undervoltage relay operated
32. AC Supply Trouble (Charger)

Separate Signal for both Charger 1, Charger 2, DCDB 1 and DCDB 2

**48 V DC**

1. Voltage of 48 V DCDB 1
2. Voltage of 48 V DCDB 2
3. Current from 48 V Battery set 1
4. Current from Battery Set 2
5. Current from 48 V Charger 1
6. Current from 48 V Charger 2
7. Battery 1 Output Voltage
8. Battery 2 Output Volatge
9. Charger Trouble 1
10. Charger Trouble 2
11. Charger 1 on Boost
12. Charger 1 on Float
13. Charger 1 Failure (Float)
14. Charger 1 Failure (FCBC)
15. Charger 2 on Boost
16. Charger 2 on Float
17. Charger 2 Failure (Float)
18. Charger 2 Failure (FCBC)

19. Charger 1 Float Current
20. Charger 1 Boost Current
21. Charger 2 Float Current
22. Charger 2 Boost Current
23. Input MCCB Incomer-1 ON (DCDB)
24. Input MCCB Incomer-2 ON (DCDB)
25. DCDB Bus coupler MCCB OFF
26. DC Earth Fault Relay Operated Sec-I
27. DC Earth Fault Relay Operated Sec-II
28. 415 V AC Supply MCCB-1 Trip
29. 415 V AC Supply MCCB-2 Trip
30. Over Temperature Indication
31. DC Overvoltage and Undervoltage relay operated
32. AC Supply Trouble (Charger)

DG Set

1. DG Set Breaker ON
2. DG Set Breaker OFF
3. Low Lube Oil Pressure
4. High Water Temperature
5. Engine Over Speed
6. Low Fuel in Service Tank
7. Over load Trip
8. Voltage RY, YB and BR
9. Current from DG set R, Y and B

Fire Fighting

1. Zone 1 Fire
2. Zone 2 Fire
3. Zone 3 Fire
4. Zone 4 Fire
5. Zone 5 Fire

Other Signal

1. PLCC Exchange Fail
2. Time Synch. Signal Fail
3. GPS Signal Fail
4. Current from Station transformer
5. Voltage from Station Transformer
6. Isolator Status of Station Transformer
7. Ambient Temperature .