BIDDING DOCUMENT
FOR

Procurement of one no. of 160MVA Transformer at 220 kV Salakati GSS, AEGCL alongwith associated works

ASSAM ELECTRICITY GRID CORPORATION LIMITED

Bid Volume II

Bid Identification No:
AEGCL/MD/Tech-1163/Salakati/160 MVA Transformer/2025/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.

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

Sl 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

3.7.2 DESIGN 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.

3.7.3 QUALITY 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 organizations."

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 organization
- 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.

3.7.5. 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

3.7.9.1 Bolts 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 400kV 220kV 132kV 33kV 11kV 415V	 Dark violet Golden yellow Sky blue Signal red Canary yellow Middle brown	 796 356 101 537 309 411	 — — — — — —	 — — — — — —
	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.

CHAPTER 3.17: TECHNICAL SPECIFICATION OF TRANSFORMER

3.17.1 **SCOPE:**

3.17.1.1 This specification provides for design, manufacture, inspection and testing before dispatch, packing and delivery at destination sub-stations of transformers complete with all fittings, accessories, spares, unloading, handling, proper storage at site, associated equipments specified herein. The scope of work shall also include, supervision of Erection, Testing and Commissioning of all the equipments supplied under this specification.

3.17.1.2 It is not the intent to specify completely herein all details of the design and construction of equipments. However, the equipment shall conform in all respects standards of engineering, design and workmanship listed in clause no. 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 equipments 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 STANDARDS:

3.17.2.1 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	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. (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 (4) Fittings and accessories for power transformers (5) Insulating oils for transformers and switchgears (6) Bushings for alternating voltages above 1000 V (7) Gas operated relays (8) Code of practice for installation and maintenance (9) Colours for ready mix paints. (10) Industrial cooling fans. (11) Guide for loading of oil immersed transformers. (12) 'Guidelines for Model Quality Assurance Plan (MQAP) for major equipment of Power sector' of CEA

3.17.2.2In case equipment conforms to other international standard which ensure equivalent or better performance than that specified under **Clause 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.

3.17.2.3 For further reference regarding standards **Annexure-V (List of Codes/Standards/ Regulations/Publications)** shall be followed.

3.17.3 GENERAL REQUIREMENT:

3.17.3.0 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 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.

3.17.3.2 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.

3.17.3.3 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.

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

3.17.3.5 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.

	17.3.1.5	Rated Capacity and Voltage of the Transformers as per present requirement of AEGCL: a) 160 MVA - 220/132/33 KV Auto Transformer with loaded 11 KV tertiary winding.

3.17.3.6 Components having identical rating shall be interchangeable.

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

160 MVA - 220/132/33 KV Auto Transformer with loaded 11 KV tertiary winding.

3.17.4 SPECIFIC REQUIREMENT:

(i) Type Test:

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.
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. **Type Test Reports of Power/Auto transformer older than five (5) years on the date of technical bid opening shall not be accepted**.
The Validity of Dynamic Short Circuit test report shall be as per CEA's notification no. CEA-TH-17/1/2021-TETD Division—dated 23rd December, 2022.
The Validity of type test report of Power/Auto Transformer and its accessories 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).

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

1. **160 MVA class Power/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**

(ii) Dynamic Effect of Short Circuit for 220 kV Class Transformer: Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on 160 MVA or above rating, 220/132/33 kV Auto transformer 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 220/132/33 kV, 160 MVA or above rating Auto–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.

(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 Guaranteed Technical Particulars

3.17.5.0 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 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 Liquidated Damages and Rejection for Excessive Losses

3.17.6.0 The offered transformer shall not have any latent design defect within ten (10) years of commissioning.

3.17.6.1 The no-load losses, load losses and auxiliary losses shall not exceed the values specified in the **Maximum losses** Clause (i.e., Clause 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.

3.17.6.2 Maximum losses:

The maximum limit of losses shall be as per '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'

Sr. No	Rating (MVA)	Voltage Rating (kV)	Phase	No Load Loss (kW)	Load Loss (kW)	I^2R (kW)	Stray + Eddy (kW)	Aux. Loss
1.	500	400/220/33	3- Phase	AT 90	500	375	125	15
2.	160	220/132	3- Phase	AT 30	200	145	55	6
3.	100	220/33	3- Phase	AT 43	245	200	45	5
4.	50	132/33	3- Phase	AT 25	125	105	20	3

3.17.7 Transportation

3.17.7.1 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.

3.17.7.2 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.

3.17.7.3 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 despatch of Transformer from factory to designated site. Requirement of Hydraulic trailer is envisaged for a load of more than 40 T.

3.17.7.4 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.

3.17.7.5 The Contractor shall despatch 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.

3.17.7.6 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.

3.17.7.7 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 Performance
3.17.8.0 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 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.

3.17.8.2 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.

3.17.8.3 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.

3.17.8.4 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.

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

3.17.8.6 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/LV** System to which the transformers will be connected is as follows:

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

3.17.8.7 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 through fault** short circuit duration of 2 seconds for Thermal stress and the same shall be verified during design review.

3.17.8.8 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.

3.17.8.9 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.

3.17.8.10 The air core reactance of HV winding of transformer of 400 kV and above voltage class shall not be less than 20%. **External or internal reactors shall not be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.**

3.17.9 Tertiary Windings (if applicable as per Annexure - A)

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/**porcelain** 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 Radio Interference and Noise Level

3.17.10.0 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 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 Measurable Defects

3.17.11.0 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 Design review

3.17.12.0 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 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.

3.17.12.2 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".

3.17.12.3 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 circuit withstand evaluation.

3.17.12.4 Type test requirement and its validity

The offered transformer or the transformer, the design of which is similar to the offered transformer, should have been successfully type tested within **last 5 years** as on the last date of submission of bid. 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. 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.

3.17.13 Construction Details

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

3.17.13.1 Tank

3.17.13.1.1 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.

3.17.13.1.2 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.

3.17.13.1.3 Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

3.17.13.1.3 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.

3.17.13.1.4 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.

3.17.13.1.5 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.

3.17.13.1.6 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

3.17.13.1.7 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.

3.17.13.1.8 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.

3.17.13.1.9 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.

3.17.13.1.6 Roller 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.

3.17.13.1.7 Conservator

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.

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 stencilled 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 aircell) with magnetic oil level gauge with potential free oil level alarm contact and prismatic oil level gauge.

3.17.13.2 Piping 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. 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 80 mm.

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 **non-carcinogenic** 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) Silicagel 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 silicagel 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

3.17.13.4.0 Pressure 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.

Pressure Relief Device:
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 in **PRV and its terminal box**. One set of potential free contacts (1NO+1NC) (with plug & socket type arrangement) per device shall be provided for tripping.

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

3.17.13.5.0 Sudden Pressure Relay

3.17.13.5.1 **Sudden Pressure relay:**
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 in SPR and **its terminal box**. Pressurized 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 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 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

3.17.10.10.3.1 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 Earthing terminal: 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 through two (2) separate earthing pits. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper.

3.17.13.9.0 Core

3.17.13.9.1 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.

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

3.17.13.9.3 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.

3.17.13.9.4 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.

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

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

3.17.13.9.7 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.

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

3.17.13.9.9 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.

3.17.13.9.10 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.

3.17.13.9.11 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.

3.17.13.9.12 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.

3.17.13.9.13 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.

3.17.13.9.14 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.

3.17.13.9.15 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.

3.17.13.9.16 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.

3.17.13.9.17 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.

3.17.13.9.18 The prime core materials are only to be used. Bidder's 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.

3.17.13.9.19 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 (Cleanroom 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 precompressed 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 ICTs with 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 transformershall 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 170 KVP without the use of any external means. **The current density of the conductor used for tertiary winding shall not exceed the current density specified for the main winding**/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 **(Heavy Load of Level-II as per latest revision of IEC 60137)** 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. **Transformer HT and LT Bushings shall be designed to withstand the seismic effect of 0.36g..**

- 420kV, 245kV, 145kV and **72.5kV** Bushings shall be either of the following type:
  a) RIP (Resin Impregnated paper) condenser type with composite polymer insulator (housing) b) 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 **72.5kV**
  Bushings..

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

  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 despatch 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.

- Bushing CT parameters indicated in the specification are tentative and liable 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, **radiator bank shall generally be placed on left side of the tank while watching from HV side of the transformer**. However, the main tank shall have provision such that cooler banks can be placed on either side of the main tank by simple reconnection 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 and for single ph. Unit connection shall be extended further to CMB.

- 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 upto 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 upto 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. Details of station auxiliary power supply are mentioned in CLAUSE 7.1.2 OF CHAPTER 7.

3.17.18.1.2 Unit cooler arrangement for transformer (if applicable)

The cooler shall be designed using Unit Cooler arrangement with capacity as specified in Annexure-A. Design of cooling system shall satisfy the performance requirements.

Each Unit Cooler shall have its own cooling fans, oil pumps, oil flow indicator, shut off valves at the top and bottom of at least 80 mm size, lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication shall be provided in the flow indicator to indicate reverse flow of oil/loss of oil flow.

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 conform to IS: 325/IEC34. 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: 4691/IEC: 34-5

The cooler, pipes, support structure and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

Expansion joint shall be provided on top and bottom cooler pipe connections as per requirement.

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.

3.17.18.1.2.1 Cooling Equipment Control (OFAF or ODAF) for Unit Coolers (if applicable)

i) Suitable manual control facility for unit cooler shall be provided.
ii) The changeover to standby unit cooler bank oil pump in case of failure of any service unit cooler shall be automatic.
iii) Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the unit cooler manually.
iv) Cooler fans & oil pumps of all unit coolers (except standby cooler) shall operate continuously. The starting of unit cooler shall be done as soon the Circuit Breaker of HV/IV/LV (as applicable) side is switched on.
v) Once started the cooling shall remain in operation as long as the transformer is in service. When the transformer is switched off the cooling shall continue to run for a further duration of 30 minutes. This timer shall be at least adjustable from 15 to 60 minutes. Further, a one-week timer is required to check the healthiness of the complete cooling system on a routine basis for one hour at a time. Spurious operation should however be avoided by appropriate settings. All settings shall be adjustable
vi) Adequate warning/ safety labels are required to indicate that the fans may start at any time.
vii) If any one group(s) is out of service and isolated, this shall not affect the automatic starting of the other unit cooler.
viii) Following lamp indications shall be provided in cooler control cabinet:
- Cooler Supply failure (main)
- Cooler supply changeover
- Cooler Supply failure (standby)
- Control Supply failure
- Cooler unit failure for each unit cooler
- No oil flow/reverse oil flow for pumps
- Thermal overload trip for each fan / pump

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and for single ph. unit connection shall be extended further to CMB.

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 color of the barrels in which Naphthenic based transformer oil is to be supplied shall be Red)

Insulating oil shall be unused un-inhibited highly refined naphthenic base oil [not containing Polychlorinated Biphenyls (PCBs)], conforming to IEC 60396-2020 & all parameters specified at Annexure – 4(T) (attached), while tested at oil supplier's premises.

The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at Annexure – 4(T), prior to despatch of oil from refinery to site. The Unused Un Inhibited Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, oil after filtration and settling are attached at Annexure – 4(T). 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 count 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.

- 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 **Type Tested design** and 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/strainless steel.

3.17.21.2 Cabling

3.17.21.2.1 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 labelled 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 / labelled for the purpose of identification.
- A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

3.17.22.1.3 OLTC Control from Common Marshalling Box (CMB)

It shall be possible to monitor, control/operate, the OLTC of all the three 1-phase transformers of a transformer bank from Common Marshalling Box. The control and monitoring terminations of a spare transformer unit (1-Ph) shall be brought to CMB. The necessary switching arrangement through male-female plug-in TB assembly shall be provided for replacing spare unit with any one of the faulty phase unit for monitoring & control from CMB.

Independent-combined-remote selector switch, raise/lower switch and emergency stop Push Button shall be provided in the common marshalling box for OLTC control.

When the selector switch is in **independent** position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.
In '**combined position'**, raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.
In **'remote position'** control of OLTC shall be possible from Digital RTCC/SCADA etc.
From CMB, the operation of OLTC shall be for 3-phases of transformer units without producing phase displacement. Independent operation of each single-phase transformer from CMB/ Digital RTCC/SCADA will be prevented.
Following minimum **LED indications** shall be provided in CMB:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 415V Main AC supply ON
h. 415V Standby AC supply ON.

Following **contacts** shall be wired to TBs in CMB for further wiring to C & R Panels.

a) 415V Main AC supply Fail
b) 415V Standby AC supply Fail

Following **contacts** shall be wired to TBs in CMB for further wiring to digital RTCC Panel:

(a) INCOMPLETE STEP
(b) OLTC motor overload protection
(c) Supply to DM Motor fail
(d) OLTC IN PROGRESS
(e) Local / Remote Selector switch positions of DM
(f) OLTC upper/lower limits reached
(g) 'Independent-combined-remote' selector switch positions of CMB

Further, OLTC Tap position Digital indications for all three 1-Ph Transformer units either separately or through selector switch shall be provided in CMB. The same shall also be wired to Digital RTCC Panel to display tap positions for all three 1-ph unit separately.

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, parameterise & 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) and common marshalling (for a bank of three 1-phase units) shall be provided.

Common marshalling box (for single phase unit) shall be floor mounted and of size, not less than 1600mm (front) X 650mm (depth) X 1800mm (height). Individual Marshalling Box and Cooler control Box shall be tank mounted or ground mounted. The gland plate hall be at least 450 mm above ground level (for ground mounted panel).

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.

The size of Common marshalling box shall not be less than 1600mm (front) X 650mm (depth) X 1800mm (height). 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:

BDV Kit as per Annexure-N of specification.
Portable DGA Kit as per Annexure-O of Specification.

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 aircell, 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 Silicagel Filter Breather with flexible connection pipes to be used during replacement of any silicagel breather.

  Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and Dehydrating Silicagel Filter Breather with flexible connection pipes to be used during replacement of any silicagel 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 17.10.1.6)
- 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 17.13.1.1.4, 17.13.1.1.7 and 17.21.1.
- **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 silicagel in silicagel 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 equipments, 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.

NIFPS system shall be supplied with operating curves indicating the actuation time of various sensors and nitrogen injection. For NIFPS system, probes and sensor locations shall not be placed inside the transformer.

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 signalling.

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-R.**

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 17.16.0. 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-Q**

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-P**

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 **(Colour: Orange)** 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-U**

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 fire**f**ighting of outdoor transformers. Spray type fire protection essentially consists of a network of projectors and 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. 43.1.1 Subsystems used to make a complete mulsifire system:

a) Main Hydrant

The main hydrant system shall be designed based on NFPA-16. This is used to carry the water to various parts of the switchyard ot transformer substation and 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 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.

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.

3.17.43.1.2 Electrical Safety

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

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

3.17.43.1.3 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.

3.17.44.0 Transformer – Connection to GIS:

Transformer connection enclosure shall be part of gas insulated metal enclosed switchgear which shall house one end of a completely immersed bushing fitted on a power transformer and main circuit end terminal of GIS. The transformer connection enclosure shall be designed as per the recommendations of IEC 62271-211 and the limit of supply of switchgear manufacturer

and the transformer manufacturer shall also be as per the scope mentioned in the IEC. The switchgear manufacturer shall supply connection between the enclosures of different phases as per requirement to limit the circulating current in the transformer tanks. The manufacturer of the connection enclosure shall take into account the total dynamic forces generated during short circuit and the enclosure as well as bushings shall be capable of withstanding vacuum during evacuation process. The switchgear manufacturer shall make necessary arrangement to limit the very fast front transient ground potential rises which may occur during switching operation. The detailed scope of transformer manufacturer and GIS manufacturer as per IEC 62271-211.
Suitable spring bellows shall be provided on the connecting GIS busduct at suitable location to prevent any vibration generating from transformer to GIS busduct.

3.17.45.0 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
Technical Particulars / Parameters of Transformers (500MVA [3 phase] 400/220/33 kV, Auto Transformer): Annexure-2(T) (Attached)

ClauseNo.	Description	Unit	Technical Parameters
1.1	Rated Capacity		
	HV	MVA	500
	IV	MVA	500
	LV (Tertiary)	MVA	5MVA (Thermal loading)
1.2	Voltage ratio (Line to Line)		400/220/33
1.3	Vector Group (3-Phase)		YNaOd11
1.4	Single / Three Phase Design		3 (THREE)
1.5	Applicable Standard		IEC 60076 / IS 2026
1.6	Cooling		ONAN / ONAF / OFAF or ONAN / ONAF / ODAF
1.7	Rating at different cooling	%	60 / 80 / 100
1.8	Cooler Bank Arrangement		2 X 50%
1.9	Frequency	Hz	50
1.10	Tap Changer (OLTC)		+10% to -10% in 1.25% steps on common end of series winding for 400kV side voltage variation
1.11	Type of Transformer		Constant Ohmic impedance type (Refer note 1)
1.12	Impedance at 75 Deg C		
	HV – IV		
	Max. Voltage tap	%	10.3
	Principal tap	%	12.5
	Min. Voltage tap	%	15.4
	HV – LV		
	Principal tap (minimum)	%	60.0
	IV – LV		
	Principal tap (minimum)	%	45.0
1.13	Tolerance on Impedance (HV-IV)	%	As per IEC, unless specified otherwise

1.14	Service		Outdoor
1.15	Duty		Continuous
1.16	Overload Capacity		IEC-60076-7
1.17	Temperature rise over 50 deg C ambient Temp		
i)	Top oil measured by thermometer	^{O}C	45
ii)	Average winding measured by resistance method	^{O}C	50
1.18	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C	^{O}C	61
1.19	Tank Hotspot Temperature	^{O}C	110
1.20	Maximum design ambient temperature	^{O}C	50
1.21	Windings		
i)	Lightning Impulse withstand Voltage		
	HV	kVp	1300
	IV	kVp	950
	LV	kVp	250
	Neutral	kVp	95
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kVp	1430
	IV	kVp	1045
	LV	kVp	275
iii)	Switching Impulse withstand Voltage		
	HV	kVp	1050
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	570
	IV	kVrms	395
	LV	kVrms	95
	Neutral	kVrms	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vii)	Tertiary Connection		Ungrounded Delta
viii)	Tan delta of winding	%	≤ 0.5
1.22	Bushing		
i)	Rated voltage		
	HV	kV	420
	IV	kV	245
	LV	kV	72.5
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	2000
	LV	A	3150
	Neutral	A	2000
iii)	Lightning Impulse withstand Voltage		

	HV	kVp	1425
	IV	kVp	1050
	LV	kVp	325
	Neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	1050
	IV	kVp	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	695
	IV	kVrms	505
	LV	kVrms	155
	Neutral	kVrms	77
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
	HV	mm	13020
	IV	mm	7595
	LV	mm	2248
	Neutral	mm	1116
vii)	Max Partial discharge level at Um		
	HV	pC	10
	IV	pC	10
	LV	pC	10
	Neutral		-
1.23	Max Partial discharge level at 1.58 * Ur / √3	pC	100
1.24	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	80
1.25	Maximum Permissible Losses of Transformers		Same for constant ohmic And constant percentage type
i)	Max. No Load Loss at rated voltage and frequency	kW	90
ii)	Max. Load Loss at rated current and frequency at75°C betweenHV and IV windings, at principal tap position	kW	500
iii)	Max. I2R loss at rated current and at 75°C for HV and IV at principal tap	kW	375
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	15

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 providedas per IS 2026 (Part 3) / IEC60076-3

Annexure – A 2.0
Technical Particulars / Parameters of Transformers (220/132/33 kV 160 MVA & 200 MVA 3-Phase Auto

Cl. No.	Description	Unit	TECHNICAL PARAMETERS	
1.	Rated Capacity			
	HV	MVA	**160**	
	IV	MVA	**160**	
	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) (unless specified differently elsewhere)		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	**72.5**
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	1250
	LV	A	**1250**
	Neutral	A	**2000**
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	1050
	IV	kVp	650
	LV	kVp	325
	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	155
	Neutral	kVrms	77
vi)	Minimum total creepagedistances		
	HV	mm	7595
	IV	mm	4495
	LV	mm	2248
	Neutral	mm	1116
viii)	Max Partial discharge level at Um		
	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		160 MVA
i)	Max. No Load Loss at rated voltage and frequency	kW	30
ii)	Max. Load Loss at rated current and at 75O C for HV and IV windings	kW	200
iii)	Max. I2R Loss at rated current and at 75O C for HV and IV windings	kW	145
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	6

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 – A 3.0

Technical Particulars/Parameters
(132/33 KV, 3-Phase Transformer)

S. No.	Description	Unit	TECHNICAL PARAMETERS		
7.1	Voltage ratio (Line-to-Line)	kV	132/33		
7.2	Rated capacity (HV and LV)	MVA	80	50	31.5
7.3	No of phases		3 (Three)		
7.4	Vector Group		YNynO		
7.5	Type of transformer		Power Transformer		
7.6	Applicable Standard		IEC 60076 / IS 2026		
7.7	Cooling type		ONAN/ONAF		
7.8	Rating at different cooling	%	60 / 100		
7.9	Cooler Bank Arrangement		2 X 50%		
7.10	Frequency	Hz	50		
7.11	Tap changer				
i)	Type		On-load tap changer (CFVV)		
ii)	Tapping range and steps		-15% to +5% in steps of 1.25% for HV variation		
iii)	Location of tap changer		On HV neutral end		
7.12	HV-LV Impedance at 75 °C, at highest MVA base				
i)	Max. Voltage tap	%	13.2		
ii)	Principal tap	%	12.5		
iii)	Min. Voltage tap	%	11.8		
7.13	Tolerance on Impedance	%	As per IEC		
7.14	Service		Outdoor		
7.15	Duty		Continuous		
7.16	Overload Capacity		IEC 60076-7		
7.17	Temperature rise over 50°C ambient temp.				
i)	Top oil measured by thermometer	^{O}C	45		
ii)	Average winding measured by resistance method	^{O}C	50		
7.18	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C		61		
7.19	Tank hot spot temperature		110		
7.20	Maximum design ambient temperature	^{O}C	50		
7.21	Windings				
i)	Lightning Impulse withstand Voltage				
	HV	kV_p	650		
	LV	kV_p	170		
	HV Neutral	kV_p	95		
	LV Neutral	kV_p	170		

ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kVp	715
	LV	kVp	187
iii)	Switching Impulse withstand Voltage		
	HV	kVp	540
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	275
	LV	kVrms	70
	HV Neutral	kVp	38
	LV Neutral	kVp	70
v)	Neutral Grounding (HV and LV)		Solidly grounded
vi)	Insulation		
	HV		Graded
	LV		Uniform
vii)	Tan delta of winding	%	≤0.5%
7.22	Bushings		
i)	Rated voltage		
	HV	kV	145
	LV, LV Neutral & HV Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	LV	A	1250 for (50 & 31.5MVA) 2000 (for 80MVA)
	HV Neutral & LV Neutral	A	1250
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	650
	LV, HV Neutral and LV Neutral	kVp	170
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	305
	LV, HV Neutral and LV Neutral	kVrms	77
v)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
	HV	Mm	4495
	LV, HV Neutral and LV Neutral	Mm	1116
vi)	Max Partial discharge level at Um on HV	pC	10
7.23	Max Partial discharge level at 1.58*Ur/√3	pC	100
7.24	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	75 for 80MVA & 50MVA 70 for 31.5MVA

7.25	**Maximum Permissible Losses of Transformers**		**80MVA**	**50 MVA**	**31.5 MVA**
i)	**Max. No Load Loss at rated voltage and frequency**	kW	**35**	**25**	**18**
ii)	**Max. Load Loss at rated current and frequency and at 75O C at principal tap between HV & LV**	kW	**200**	**125**	**110**
iii)	**Max. I2R Loss at rated current and frequency and at 75O C at principal tap between HV & LV**	kW	**170**	**105**	**93.5**
iv)	**Max. Auxiliary Loss at rated voltage and frequency**	kW	**5**	**3**	**2**

Notes:

1. For parallel operation with existing transformer, percentage impedance, OLTC connection & range, vector group 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 providedas per IS 2026 (Part 3) / IEC60076-3

Annexure – A 4.0

Technical Particulars/Parameters
(220/33 KV, 100 MVA 3-Phase Transformer)

Cl. No.	Description	Unit	Technical Parameters
6.1	Voltage ratio (Line-to-Line)	kV	220/33
6.2	Rated Capacity		
	HV	MVA	100
	LV	MVA	100
6.3	No of phases		3 (Three)
6.4	Vector Group		YNyn0
6.5	Type of transformer		Power transformer
6.6	Applicable Standard		IEC 60076 / IS 2026
6.7	Cooling type		ONAN / ONAF / OFAF or ONAN/ONAF/ODAF
6.8	Rating at different cooling	%	60 / 80 / 100
6.9	Frequency	Hz	50
6.10	Cooler Bank Arrangement		2 X 50%
6.11	Tap Changer		
i)	Type		On-load tap changer
ii)	Tap range and steps		-15% to +5% in steps of 1.25% for HV variation
iii)	Location of tap changer		On HV neutral end
6.12	Impedance at 75°C, at highest MVA Base		
i)	Max. Voltage tap	%	16.2

ii)	Principal tap	%	15.0
iii)	Min. Voltage tap	%	14.0
iv)	Tolerance on Impedance		As per IEC
6.13	Service		Outdoor
6.14	Duty		Continuous
6.15	Overload Capacity		IEC-60076-7
6.16	Temperature rise over 50 deg C ambient Temp		
i)	Top oil measured by thermometer	^{O}C	45
ii)	Average winding measured by resistance method	^{O}C	50
6.17	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C	^{O}C	61
6.18	Tank Hotspot Temperature	^{O}C	110
6.19	Maximum design ambient temperature	^{O}C	50
6.20	Windings		
i)	Lightning Impulse withstand Voltage		
	HV	kV_p	950
	LV	kV_p	170
	HV Neutral	kV_p	95
	LV neutral	kV_p	170
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kV_p	1045
	LV	kV_p	187
iii)	Switching Impulse withstand Voltage		
	HV	kVp	750
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	395
	LV	kVrms	70
	HV Neutral	kVrms	38
	LV neutral		70
v)	Neutral Grounding (HV & LV)		Solidly grounded
vi)	Insulation		
	HV		Graded
	LV		Uniform
vii)	Tan delta of winding	%	≤ 0.5
6.21	Bushing		
i)	Rated voltage		
	HV	kV	245
	LV	kV	36
	HV Neutral	kV	36
	LV Neutral		
ii)	Rated current		
	HV	A	1250
	LV	A	3150
	HV Neutral	A	3150
	LV neutral		3150
iii)	Lightning Impulse withstand Voltage		

	HV	kVp	1050
	LV	kVp	170
	HV Neutral	kVp	170
	LV neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	505
	LV	kVrms	77
	Neutral	kVrms	77
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
	HV bushing	mm	7595
	LV bushing	mm	1116
	HV neutral / LV neutral	mm	1116
vii)	Max Partial discharge level at Um		
	HV	pC	10
6.22	Max Partial discharge level at 1.58 * Ur / √3	pC	100
6.23	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	80
6.24	**Maximum Permissible Losses of Transformers**		
i)	Max. No Load Loss at rated voltage and frequency	kW	43
ii)	Max. Load Loss at rated current and at 75°C for HV and LV windings at principal tap position	kW	245
iii)	Max. I2R Loss at rated current and at 75° C for HV and LV windings at principal tap position	kW	200
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	5

Notes:

1. For parallel operation with existing transformer, percentage impedance, OLTC connection & range, vector group 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 providedas per IS 2026 (Part 3) / IEC60076-3
6. **For 220 kV Class Transformer:**
   Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on 160 MVA or above rating,220/132/33 kV Auto transformer 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 220/132/33 kV, 160 MVA or above rating Auto–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.

Annexure–B
Design Review Document

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics upto $1.7U_m$
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 tank process as per IS:3618 & IS:6005	Zinc chromate Primer (two coats)	--	EPOXY paint with PU top coat or POWDER coated	Minimum 80µm / for powder coated minimum 100µm	RAL 7035 shade for exterior and Glossy 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- F
RATING & DIAGRAM PLATE

The transformer shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the appropriate items indicated below. The entries on the plate shall be in English in indelibly marked.

Minimum Information to be provided on the plate:

Manufacturer's name, country and city where the transformer wasassembled					
MVA Rating, Voltage ratio, Type of transformer (for example 315MVA400/220/33kV Auto Transformer)					
Type of Cooling			Applicable Standard		

Rated Power at different cooling			Rated frequency	Hz	
HV/IV	MVA	--/--/--	Number of phases		
LV	MVA		% Impedance / OhmicImpedance		
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 ratedvoltage and atprincipal tap	dB		Transformer oil Quantity	Ltrs	
Tan delta of winding			Paint Shade		
Moisture content	ppm		No load loss at ratedvoltage & frequency	KW	
Manufacturer's Serial number			Load loss at rated current & frequency (at75^0C) for HV & IV/LV winding	KW	
Year of manufacture			I^2R loss at rated current & frequency (at 75^0C) forHV & IV/LV winding	KW	
Work Order No.			Auxiliary loss at ratedvoltage & 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) installedin transformer like the location, core Nos., ratio(s), accuracy class, rated output (VA burden), knee point voltage, magnetizing current, maximumCT 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 nameplate.

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 Bushing Current Transformer and Neutral Current Transformer Parameters (On each phase) for 3-ph, 500MVA 400/220/33 kV Transformers:

Description	**Bushing Current Transformer Parameters (Transformer)**		
	HV Side	IV Side	Neutral Side
Ratio			
CORE 1	1600/1	1600/1	1600/1
CORE 2	1000/1	1600/1	-
CORE 3	Refer to note 1		
Minimum knee point voltage or burden and accuracy class			
CORE 1	1600V, PX / PS	1600V, PX / PS	1600V, PX / PS
CORE 2	0.2S Class 20VA ISF≤5	0.2S Class 20VA ISF≤5	-
CORE 3	Refer to note 1		
Maximum CT Secondary Resistance			
CORE 1	4.0 Ohm	4.0 Ohm	4.0 Ohm
CORE 2	-	-	-

CORE 3	Refer to note 1		
Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	-
CORE 3	Refer to note 1		
Maximum magnetization current (at knee point voltage)			
CORE 1	25 mA	25 mA	25 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.

2.0 Technical Parameters of Bushing Current Transformers and Neutral Current Transformers for 160MVA 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	600V, PX / PS	600V, PX / PS	600V, PX / PS
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.

3 Technical Parameters of Bushing Current Transformer and Neutral Current Transformer for 50 MVA 132/33 kV 3-Ph Transformers:

Description	**Bushing Current Transformer Parameters (Transformer)**			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
(a) Ratio				
CORE 1	300/1	300/1	1000/1	1000/1
CORE 2	300/1	300/1	1000/1	1000/1
CORE 3	Refer to note 1			
(b)Minimum knee point voltage or burden and accuracy class				
CORE 1	600V, PX / PS	600V, PX / PS	1000V, PX / PS	1000V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	600V, PX / PS	0.2S Class 15VA ISF ≤ 5	1000V, PX / PS
CORE 3	Refer to note 1			
(c)Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	1.5 Ohm	-	1.5 Ohm

CORE 3	Refer to note 1			
(d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Restricted Earth fault	Metering	Restricted Earth Fault
CORE 3	Refer to note 1			
(e)Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	100 mA	100 mA
CORE 2	-	100 mA	-	100 mA
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.

6.0 Technical Parameters of Bushing Current Transformer and Neutral Current Transformer for 100 MVA 220/33 kV 3-Ph Transformers:

Description	**Bushing Current Transformer Parameters (Transformer)**			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
(a) Ratio				
CORE 1	300/1	300/1	2000/1	2000/1
CORE 2	300/1	300/1	2000/1	2000/1
CORE 3	Refer to note 1			
(b)Minimum knee point voltage or burden and accuracy class				
CORE 1	600V, PX / PS	600V, PX / PS	2000V, PX / PS	2000V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	600V, PX / PS	0.2S Class 15VA ISF ≤ 5	2000V, PX / PS
CORE 3	Refer to note 1			
(c)Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	1.5 Ohm	-	1.5 Ohm
CORE 3	Refer to note 1			
(d) Application				

CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Restricted Earth Fault	Metering Fault	Restricted Earth Fault
CORE 3	Refer to note 1			
(e)Maximum Magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	100 mA	100 mA
CORE 2	-	100 mA	-	100 mA
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 down trend
- 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). For such type of transformer test may be carried out with the following sequence:

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 IEC 60567.

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 (Max MVA).

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 IEC 60567.

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 IEC 61181.

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 IEC 60076-2
- 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 furnished with the test certificates and shall include at least the following.

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 (upto 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 less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

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 (in mm)	Permanent deflection of flat plate (in mm)
Up to and including 750	5.0
751 to 1250	6.5

1251	to	1750	8.0
1751	to	2000	9.5
2001	to	2250	11.0
2251	to	2500	12.5
2501	to	3000	16.0
Above		3000	19.0

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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 IEC 60137.

Annexure - I
Test Plan

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	Routine	Routine

	temperature rise test is performed)		
19.	Measurement of no load current & Short circuit Impedance with 415 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)
Temperature Range: 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 IEC 60599-1999.

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 at least three years without replacement. All the consumable (if any) upto 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 as under:

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 (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 form 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 set up. During this period, if the kit needs to be shifted to suppliers 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	Automatic Transformer Oil BDV Testing Kit	DTA-100C (BAUR), OTS100AF-UKU-PX (Megger)
2	Oil Storage Tank (With Wheels)- 20kL Capacity	VPI / CEE DEE VACUUM / SICORP
3	Stainless Steel Oil sampling bottle (One Litre Capacity)	SCIENO TECH 1 litre
4	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.
1.2 Separate cables shall be used for DC1 & DC2.
1.3 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.
1.4 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.
1.5 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.
1.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.
1.7 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.
1.8 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.
1.9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).
1.10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.
1.11 Repaired cables shall not be accepted.
1.12 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.
1.13 **PVC Power Cables**
1.13.1 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.

1.14 **PVC Control Cables**

1.14.1 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.

1.14.2 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 DATA SHEET (1.1kV GRADE XLPE POWER CABLES)

Sr. No	Description	Parameters	
1a	Cable Sizes	1 C x 630	3½ C x 300
b	Manufacturer's type designation	A2XWaY	A2XWY
2	Applicable standard	IS: 7098/PT-I/1988 & its referred Specifications	
3	Rated Voltage(volts)	1100 V Grade	
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 aambient temp. of 50°C and for maximum conductor temp. of 70 °C of PVC Cables[For information only]	732	410
7	Rating factors applicable to the current ratings forvarious conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 secduration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA	45kA	45kA
b	Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above	250°C	
9	Conductor		
a	Material	Stranded Aluminium as per Class 2 of IS : 8130	
b	Grade	H 2 (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	Outermost layer shall be R.H lay & opposite in successive layers	
10	Conductor resistance (DC) at 20 °C per km-maximum	0.0469	0.1/0.206
11	Insulation		
a	Composition of insulation	Extruded XLPE as per IS-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	Extruded PVC type ST-2 as per 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

Sr. No	Description	Parameters	
13	Armour		
a	Type and material of armour	Al wire [H4 grade]	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 0.12 sec at room temperature.	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 oC	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	colour of sheath	$	$
15a	Nominal Overall diameter of cable	+2/-2 mm	
b	Tolerance on overall diameter (mm)	shall conform to IS 10418 and technical specification	
16	Cable Drums	1000/500	1000/500
a	Max./ Standard length per drum for each size ofcable (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 ofproject)	
17	Whether progressive sequential marking on outersheath provided at1 meter interval 18	Yes	
18	Identification of cores		
a	colour of cores	As per IS 7098 Part(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 - 1.1kV kV GRADE PVC POWER CABLES

SN	Description	Parameters					
1a	Cable Sizes	1 c x 150	3.5 c x 70	3.5 c x 35	4 c x 16	4c x 6	2 c x 6
1b	Manufacturer's type designation	AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards					
3	Rated Voltage(volts)	1100 V grade					

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 laid in air in a ambient temp. of 50oC and for maximum conductortemp. of 70 deg C of PVC Cables [For information only]	202	105	70	41	24	28
7	Rating factors applicable to thecurrent ratings for various conditions of installation:	As per IS-3961-Pt-II-67					
8	Short circuit Capacity						
a)	Short Circuit Amp. (rms)KA for 1 sec duration	11.2	5.22	2.61	1.19	0.448	0.448
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C					
9	Conductor						
a)	Material	STRANDED ALUMINIUM					
b)	Grade	H 2 (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.)	as per Table 2 of IS 8130					
e)	Form of Conductor	Non-compacted Stranded circular	shapedconductor	shaped conductor	shaped conductor	Non-compacted Stranded circular	Non-compacted Stranded circular
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive Layer					
10	Conductor resistance (DC) at 20oC per km-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-I as per 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	as per IS 3975/88					
a)	a) Type and material of armour	Al. Wire[H4 grade]	Gal.steelstrip	Gal.steel strip	Gal.steel strip	Gal.steel wire	Gal.steelwire
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 roundarmour 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 infoonly	K x A√t (K Amp) (where A = total area of armour in mm²& t = time in seconds), K=0.091 for Al & 0.05 forsteel					
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	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	e) Guaranteed value of minimum temperature index at 21 oxygenindex	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
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/-2 mm					
16	Cable Drums	shall conform to IS 10418 and technical specification					
a)	a) Max./ Standard length per drumfor each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
b)	b) Non standard drum lengths	Maximum one (1) non standard lengths of each cable sizemay be supplied in drums only over & above the standardlengths 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,Bl& 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					

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

Sl. No	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c cx 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 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)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed or unearthed system	for both							
6	Continuous current rating when laid in air ina ambient temp. of 50oCand for maximum conductor temp. of 70 oC of PVC Cables[For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicableto the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp. (rms)KA for 1 sec duration	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(deg C.)	160^0C							
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.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 oC per km-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-I as per IS-5831-84							

b)	Calculated diameter overthe 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 IS 3975/99							
a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter ofcable 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 the armour along for 1sec-for info only	0.05 x A√t (K Amp)(where A = total area of armour in mm2 & t =time in seconds)							
g)	DC resistance at 20 oC(Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
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 at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size ofcable (single length) with ±5% Tolerance(mtrs)	1000/500							
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								
18	Identification of cores	Yes							
a)	colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offeredare ISI marked	YES							
20	Whether Cables offered are suitable for laying asper IS 1255	YES							

$'- As per manufacturer design data

ANNEXURE-N

Technical Specification of Oil BDV Test Set (If specified in BPS)

Item	**Specification**
Functional Requirement	1. The instrument should be suitable for Automatic Measurement of Electrical Breakdown Strength of Transformer oil as per relevant standards. 2. The test results should have repeatability, consistency in laboratory condition.
Test Output	0-100 kV (Rate of rise: 0.5 to 5KV/Sec)
Accuracy	± 1 kV
Resolution	0.1 KV
Switch off Time	≤ 1ms
Display/Control	LCD/Keypads.
Printer	Inbuilt/External
Measurement Programmes	Fully Automatic Pre-programmed/User programmed Test Sequences including as per latest IEC & other national/international standards.
Test Lead/ Accessories	One complete set of electrodes, gauge etc. compatible with the instruments should be provided for successfully carrying out the test in EMPLYER S/S. Additionally, all the required accessories, tools, drawing, documents should be provided forthe smooth functioning of kit. Further hard carrying case (which should be robust/rugged enough) for ensuring proper safety of the kit during transportation shall have to be provided.
Design/Engg.	The complete equipment along with complete accessories must be designed / engineered by Original Equipment Manufacturer.
Power Supply	It shall work on input supply variations, V: 230 ±10 %, f: 50 Hz ±5 % on standard sockets.
Operating Temperature	0 to +50 deg C
Relative humidity	Max. 90% non-condensing.
Protection/ Control	Against short circuit, over load, transient surges etc. Also the instrument should have facility of stopping automatically on power failure. Also the kit should have facility of HV chamber interlocking as well as zero start interlocking.
Environment	The test kit shall be compatible for EMI/EMC/Safety environment requirement as per IEC.

Guarantee	Warranty/Guarantee Period: Min 05 year from the date of successful & complete commissioning at Employer sub-station. All the materials, including accessories, cables, laptops etc. are to be covered under warranty/guaranty period. If the kit needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, software, and transportation of kit for repair at test lab / works.
Calibration Certificate	Unit shall be duly calibrated before supply and the date of calibration shall not be older than two months from the date of supply of Kit.
Training	Supplier shall have to ensure that the instrument is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrange necessary training to EMPLYER engineers.
Commissioning, handing over the Instrument	Successful bidder will have to commission the instrument to the satisfaction of EMPLOYER. The instrument failed during the demonstration shall be rejected and no repairs are allowed.
After sales service	Bidder will have to submit the documentary evidence of having established mechanism in India for prompt services.

ANNEXURE - O

Technical Specification of Portable Dissolved Gas Analysis of Oil (If specified in BPS)

Sl No.	Particulars	Specification
01	Functional Requirement	The Portable DGA equipment to extract, detect, analyze and display the dissolved gases in insulating oil as specified in IEEE C 57-104- 2008 and IEC 60599-2007.
02	Detection of Gases	All the fault gases i.e. H2, CH4, C2H2, C2H4, C2H6, CO & CO2 concentrations shall be individually measured and displayed. The minimum detection limits of the instrument for the above gases shall strictly be met the requirement of IEC-60567-2011-Page No. 47- clause 9.2, table-5.
03	Power Supply	It shall be operated with AC single phase,50 Hz +/-5%, 230 V +/- 10% supply. All power cable and necessary adaptors shall be provided by supplier.
04	Instrument control and Data handling, Internal Memory	a) Instrument shall be having in-built control for all the functions (data acquisitions and data storage), it shall have a facility for communication with computer for downloading the data from instrument via USB port. b) Laptop shall be provided for communication with the instrument. it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999. Laptop carrying case shall also be provided. c) Internal Memory can capable of store atleast 15000 records
05	General Conditions	a) Performance Parameters like - Minimum Detection Limits, Working Range, Accuracy, repeatability etc. shall be finalized during detailed engineering. b) The portable DGA equipment supplier shall demonstrate during commissioning of the kit that the results shown by the kit are within the specified accuracy and repeatability range and EMPLOYER will provide only the insulating oil/ GAS-IN-OIL standard for testing. c) All required items/instruments /spares /consumable /connecting cables/communication cables/instruments/manuals/Certificates/training materials/original software/original licensed data/station operating software/education CD/DVDs that are essential to understand and operate the instrument shall be supplied at no extra cost.
06	Operating Temperature, Relative humidity & Dimensions	01. Temperature 0-50 Deg. C 02. 85% non-condensing 03. Portable
07	Warranty	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 set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works.
08	Service Support	The supplier shall furnish the requisite documents ensuring that the equipment manufacturer is having adequate service team and facility in India to take care of any issues during operation of the instrument.
09	Training	The supplier shall provide adequate training for a period of two working days pertaining to the operation and troubleshooting to site personnel.

ANNEXURE - P

On Line Dissolved Hydrogen and Moisture Monitor

1.0 Online Dissolved Hydrogen 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 IEC 60599-1999

2.0 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

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 inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. All the consumable (if any) upto 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 deg C
	Operating Oil Temperature	– 20 to + 105 deg C
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

9.0 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 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.

11.0 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 set up. During this period, if the kit needs to be shifted to suppliers 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 - Q

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 5 LPM).

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. The equipment shall be capable of transferring data to substation automation 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 set up. During this period, if the kit needs to be shifted to suppliers 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 - R

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 othertrip 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) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to 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
   - 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
   - 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 5 mm) 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 (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethane (PU) (Minimum 50µm)	Minimum 155µm	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 finalized 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-S

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 wideenough 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 - T

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 meters 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 fitted 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 up to 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 up to 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-55 enclosure.

ANNEXURE – U

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 0° C to +80 ° C.

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 any time.

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 analyzing 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 suppliers works for repairs, supplier will have to bear the cost of, spares, software, 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-V

LIST OF CODES/STANDARDS/REGULATIONS/PUBLICATIONS

A list of Codes/Standards/Regulations/Publications which shall be used fordesign review, manufacturing, testing, erection, transportation etc. has been given below. In case of revision/amendment of these, revised/amended versions shall be followed.

IS 2026: Part 1 : 2011 (Reaffirmed Year : 2016)	-	Power transformers: Part 1 General
IS 2026: Part 2 : 2010 (Reaffirmed Year : 2020)	-	Power transformers Part 2 Temperature-rise
IS 2026: Part 3 : 2018	-	Power Transformers Part 3 InsulationLevels, Dielectric Tests and ExternalClearances in Air (Fourth Revision)
IS 2026: Part 4 : 1977 (Reaffirmed Year : 2016)	-	Power transformers: Part 4 Terminal marking, tapings and connections
IS 2026 : Part 5 : 2011 (Reaffirmed Year : 2016)	-	Power Transformers Part 5 Ability toWithstand Short Circuit
IS 2026 : Part 6 : 2017	-	Power Transformers Part 6 Reactors
IS 2026 : PART 7 : 2009 (Reaffirmed Year : 2019)	-	Power Transformers Part 7 Loading Guidefor Oil-Immersed Power Transformers
IS 2026 : Part 8 : 2009 (Reaffirmed Year : 2019)	-	Power Transformers : Part 8 Applicationsguide
IS 2026 : Part 10 : 2009 (Reaffirmed Year : 2019)	-	Power Transformers : Part 10 Determinationof sound levels
IS 2026 : Part 10 : Sec 1 : 2018	-	Power Transformers part 10 Determinationof Sound Levels Section 1 Application guide
IS 2026 : Part 14 : 2018	-	Power Transformers Part 14 Liquid- Immersed Power Transformers Using High- Temperature Insulation Materials
IS 2026 : Part 18 : 2018	-	Power Transformers Part 18 Measurement ofFrequency 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 electrotechnical 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 Medium and 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 ElectricSupply) 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 (Publication No. 317)		
ISO 9001: Quality System – Model for Quality Assurance in Design/Development.		
ISO-14001 (Environmental Management System)		
OHSAS 18001 (Occupational Health and Safety Management System)		

Annexure-W

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 transformerand reactor manufacturer:

1. EOT Crane for main manufacturing bay and other shops (With Load Cell).
2. Vapor Phase Drying Oven (adequately sized to accommodate offeredtransformer and have facility to record temperature, vacuum, moisture etc.)
3. Air Casters for material handling
4. Core cutting line (if applicable)
5. Vacuum auto claves
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 400 kV & 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 (for 400 kV & above Transformer/reactor)
41. Multimeters

Manufacturing environment (Clean, dust free and humidity-controlledenvironment)

A. Transformer must be manufactured in a bay having positive pressure w.r.t. external environment. Winding shall be manufactured ina clean, dust free and humidity-controlled environment. The dust particleshall 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 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)

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.	
	Calculated/guaranteed iron loss in KW at:	

Sl. No	Particulars	Values
5.	(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	
	(ii) At maximum tap position	
	(iii) At minimum tap position	
12.	Resistively of copper to be used for winding	
13.	I²R 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 [I²R]loss + stray	
	(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)

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/lot	TM Spec	Insp.record	Vendor/TM QC	TC Review
1.3.2		Dielectric	Testing	Sampling/l	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
		Strength		ot		ord	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/Rati ng	-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 (WxDxH of 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 interturn 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/T esting	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	Inspectio n 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) Checkinsulation 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' s QC	**In process check card review by Customer**
		(ii) Check for completeness of drying	VPD Data	Each Unit	TM's Spec	Insp Record	TM's testing/TM' s QC	**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's QC	**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 acousticnoiselevel						

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

3. Further details of MQP shall be as per 'Guidelines for Model Quality Assurance Plan (MQAP) for major equipment of Power sector' of CEA.

CHAPTER 3.18: TECHNICAL SPECIFICATION FOR SURGE ARRESTERS FOR 400KV, 220KV, 132KV & 33KV SYSTEMS

3.18.1 SCOPE

3.18.1.1 This Section covers the specifications for design, manufacture, testing, transportation delivery at site, erection, and commissioning of class heavy duty, gapless metal (zinc) oxide Surge Arrestors complete with fittings & accessories for 400 kV, 220 kV, 132 kV and 33 kV systems.

3.18.2 STANDARDS

3.18.2.1 The design, manufacture and performance of Surge Arrestors shall comply with IS: 15086 Part-4 / IEC: 60099-4 unless otherwise specifically specified in this Specification

3.18.3 GENERAL REQUIREMENT

3.18.3.1 The surge arrestor shall draw negligible current at operating voltage and at the same time offer least resistance during the flow of surge current. **The surge arrester shall be used in solidly earthed system**.

3.18.3.2 The surge arrestor shall consist of non-linear resistor elements placed in series and housed in electrical grade porcelain housing of specified creepage distance.

3.18.3.3 The assembly shall be hermetically sealed with suitable rubber gaskets with effective sealing system arrangement to prevent ingress of moisture.

3.18.3.4 The surge arrestor shall not operate under power frequency and temporary over voltage conditions but under surge conditions, the surge arrestor shall change over to the conducting mode.

3.18.3.5 The surge arrestor shall be suitable for circuit breaker performing 0-0.3sec.-CO-3min-CO- duty in the system.

3.18.3.6 Surge arrestors shall have a suitable pressure relief system to avoid damage to the porcelain housing and providing path for flow of rated fault currents in the event of arrestor failure..

3.18.3.7 The reference current of the arrestor shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

3.18.3.8 The Surge Arrestor shall be thermally stable and the bidder shall furnish a copy of thermal stability test with the bid.

3.18.3.9 The arrestor shall be capable of handling terminal energy for high surges, external pollution and transient over voltage and have low losses at operating voltages.

3.18.4 ARRESTOR HOUSING

3.18.4.1 The arrestor housing shall be made up of porcelain housing 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. Arrestors shall be complete with insulating bases, fasteners for stacking units together, surge counters with leakage current meters and terminal connectors.

3.18.4.2 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 arrestor. The arrestors shall not fail due to contamination. The arrester housings shall be designed for pressure relief class as given in Technical Parameters of the specification.

3.18.4.3 Sealed housings shall exhibit no measurable leakage.

3.18.5 FITTINGS & ACCESSORIES

3.18.5.1 The surge arrestor shall be complete with insulating bases, fasteners for stacking units together, surge counters with leakage current meters and terminal connectors.

3.18.5.2 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 arrestor shall be galvanized. The line terminal shall have a built-in clamping device which can be adjusted for both horizontal and vertical takeoff.

3.18.5.3 Grading corona control rings if necessary, shall be provided on each complete arrestor pole for proper stress distribution.

3.18.6 SURGE MONITOR

3.18.6.1 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 scale range **of 0 to 5mA peak/root 2 to** measure leakage current of surge arrestor shall also be supplied within the same enclosure. The number of operations performed by the arrestor shall be recorded by a suitable non-resettable 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 suitable for communication to SCADA in the control room if the leakage current exceeds the permitted value. Similar provision shall be considered for surge counter also.

3.18.6.2 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 of **minimum 5kV rating** up to grounding point and bends shall be minimum.

3.18.7 TESTS

3.18.7.1 Test on Surge Arrestors

The Surge Arrestors offered shall be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 15086 (Part-4). In addition, the suitability of the Surge Arrestors shall also be established for the following:

- Residual voltage test
- Reference voltage test
- Leakage current at M.C.O.V
- P.D. test
- Sealing test
- Thermal stability test
- Aging and Energy capability test
- Watt loss test

Each metal oxide block shall be tested for guaranteed specific energy capability in addition to routine/acceptance test as per IEC/IS.

3.18.7.2 The surge arrestor housing shall also be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 2071.

3.18.7.3 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.

3.18.8 NAME PLATE

3.18.8.1 The name plate attached to the arrestor shall carry the following information:

Rated Voltage
Continuous Operation Voltage
Normal discharge current
Pressure relief rated current
Manufacturers Trade Mark
Name of Sub-station
Year of Manufacturer

Name of the manufacture
Purchase Order Number along with date.
Energy Absorption Capability

3.18.9 PRE-COMMISSIONING TESTS

3.18.9.1 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 along with 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) Third harmonic resistive current measurement (to be conducted after energization)

3.18.10 TYPE AND RATINGS may be read as:

SL No.	Particulars	420 kV	245 kV	145 kV	36 kV
I	**II**	**III**	**IV**	**V**	**VII**
1	Rated voltage of arrester, kV	398	216	120	30
2	Continuous operating voltage, kV	267	168	102	25
2	Rated frequency, Hz	50	50	50	50
3	Nominal discharge current of arrester, kA	20	20/10	10	10
4	(i) Min. switching surge residual voltage (2kA),kVp	IEC	IEC	IEC	IEC
	(i) Max. switching surge residual voltage (500 kA),kVp	IEC	IEC	IEC	IEC
5	Maximum residual voltage at,				
	(i) 5 kA nominal discharge current, kV (peak)	IEC	IEC	IEC	IEC
	(ii) 10kA nominal discharge current, kV (peak)	IEC	IEC	IEC	IEC
	(iii) 20kA nominal discharge current, kV (peak)	IEC	IEC	IEC	IEC
	(iv) Steep fronted wave residual voltage, kV (peak)	IEC	IEC	IEC	IEC
6	One minute power frequency withstand voltage of arrester housing, kV (rms)	650	460	275	70
7	1.2 / 50 second impulse withstand voltage of arrester housing, kV (peak)	1425	1050	650	170
8	Switching impulse withstand voltage (250/2500 micro second) of arrester housing dry and wet, kV (peak)	1050	-	-	-
9	Creepage distance of insulator housing (mm)	13020	7595	4495	1116

10	Line discharge class	4	3	3	3
11	Short time current rating, kA for 3 sec	63	50	40	31.5
12	Pressure Relief Class	A	A	A	A
13	Minimum cantilever strength (upright)	10kN	8N	6KN	4KN

CHAPTER 3.19: TECHNICAL SPECIFICATION FOR ISOLATORS (AIS)

3.19.1 TECHNICAL PARTICULARS OF 400 kV, 220 kV, 132 kV & 33 KV ISOLATOR are as follows:

	Type:	400 kV	220 kV	132 kV	66 kV	33 kV
I	II	III	IV	V	VI	VII
1	Main switch	Centre break/Pantograph	Horizontal Centre break/double break	Horizontal Centre Break/double break	Horizontal Centre break	Horizontal Double break
2	Service	Outdoor				
3	Applicable standard	IS : 9921 / IEC-62271-102				
4	No. of Phases	3 phase				
5	Design Ambient temperature	50°C				
6	Type of operation	Electrically Ganged	Mechanically Ganged			
7	Rated voltage (kV)	In KV	In KV	In KV	In KV	In KV
	a) Nominal	400	220	132	66	33
	b) Maximum	420	245	145	72.5	36
8	Rated current (Amps)	As per approved SLD				
9	Short time current for 1sec.(kA)	63	50	40	31.5	31.5
10	Rated frequency	50 HZ ± 5%				
11	System earthing	Effectively earthed				
12	Temperature rise	As per relevant IS/IEC standards				
13	Lightening Impulse withstand voltage (kVp)					
	(a) Across Isolating distance	1425(+240)	1220	750		195
	(b) To earth	1425	1050	650		170
14	1-minute power frequency					

	Type:	400 kV	220 kV	132 kV	66 kV	33 kV
I	II	III	IV	V	VI	VII
	withstand voltage					
	a) Across Isolating distance	815	605	315		80
	b) To earth	650	460	275		70
15	Switching Impulse withstand voltage (kVp)					
	a) Across Isolating distance	900(+345)	-	-		-
	b) To earth	1050	-	-		-
16	Max. RIV for frequency between 0.5MHz and 2MHz (micro-volt)	1000 at 267kV	1000 at 156kV	500 at 92kV		-
17	Corona Extinction Voltage (kV)	320	-	-		-
18	Operating mechanism					
	a) Isolator	Motor	Motor	Motor	Motor	Motor
	b) Earth switch	Motor	Motor	Motor	Manual	Manual
19	Auxiliary voltage					
	a) Control & Interlock		110V/ 220V DC 80% to 110%			
	b) Motor voltage		3 Phase 415V AC 50Hz			
	c) Heater, lamp & socket		Single phase 240 V 50HZ			
20	Safe duration of overload					
	150% of rated current		5 minute			
	120% of rated current		30 minute			
21	Minimum creepage distance of insulator (mm)					
22	Mounting structure	Tubular / Lattice	Tubular / Lattice	Tubular / Lattice	Tubular / Lattice	Tubular / Lattice
23	Operating time		Less than 12 secs			
24	Insulator Data					
	a) Bending Strength (kgf)	1000	800	800		600
	b) Height (mm)	3650	2300	1500		508

	Type:	400 kV	220 kV	132 kV	66 kV	33 kV
I	II	III	IV	V	VI	VII
	c) Bottom PCD (mm)	300	254	184	As per IS/IEC	76
	d) No. of holes & hole dia.	8x18	8x18	4x18		4xM12
	e) Top PCD	127	127	127		76
	f) No. of holes & hole dia.	4xM16	4xM16	4xM16		4xM12
	g) Minimum creepage distance (mm) 31mm/kV	13020	7595	4495	2248	1116
25	Working clearance (live part to ground) (in mm)	8000	5900	4900	As per IS/IEC	4000
26	Phase Spacing (mm.)	6000	4000	3000		1500
27	Minimum clearances (mm.)					
	a) Phase to Phase	4000	2100	1300		320
	b) Phase to earth	3500	2100	1300		320
	c) Sectional clearance	6500	5000	4000		3000

3.19.2 SCOPE

This specification provides for design, manufacturer, testing at manufacturer's Works and delivery, supervision of erection, commissioning (if required) of outdoor station type 400kV/220KV/132KV/ 33KV, Isolator with/ without earth switches, with electrical/**mechanical** interlock, insulators and complete in all respect with bimetallic connectors arcing horns operating mechanism, auxiliary switches, indicating devices, fixing detail etc. as described hereinafter.

3.19.3 STANDARDS

Disconnecting switches covered by this specification shall conform to latest edition IEC-129/IEC 62271-102 I.S.1813 and IS: 9921, IS-325 and unless specifically stated otherwise in this specification.

3.19.4 TYPE

The 400,220&132 KV Isolators shall be outdoor type with centre break type/double break/Pantograph type as required [Single(SI)/ Double(DI)] Isolators suitable for electrical as well as manual operation and local/ remote operation; but 33KV Isolators (SI or DI) shall be outdoor type with three phase double break center rotating manual as well as motor operated type with local/remote operation. They shall have crank and reduction gear mechanism.

All Isolators offered shall be suitable for horizontal upright mounting on steel structures. Each pole unit of the multiple Isolators shall be of identical construction and mechanically linked for gang operation.

Each pole of the Isolator shall be provided with two sets of contacts to be operated in series and the moving contact blades shall rotate in horizontal plane.

The design shall be such that the operating mechanism with the linkages shall be suitable for mounting on any of the outer pole ends without much difficulty and with minimum shifting of parts.

Moving contacts of all isolators shall rotate through 90 deg. from their “fully closed position” to “fully open position so that the break is distinct and clearly visible from ground level.

The Isolators offered by the Bidder shall be designed for Normal rating current for Isolator as follows:

400kV	220kV	132kV	66kV	33kV
4000A	3150A/1600A	2000/1600/1250A	2000/1250A	2500/1600/1250A

It should suitable for continuous service at the system voltages specified herein. The Isolators shall be suitable to carry the rated current continuously and full short circuit current of 63/50/40/31.5 KA for 400/220/132/33 KV respectively for 1 second at site condition without any appreciable rise in temperature. These shall also be suitable for operation at 110% rated (normal) voltage. The Isolators shall be suitable for Isolating low capacitive / inductive currents of 0.7amp at 0.15 power factor. The isolators shall be so constructed that they don’t open under the influence of short circuit conditions.

The Isolators and earthing switches are required to be used on electrically exposed installation and this should be taken into account while fixing the clearance between phases and between phase and earth. so that de-energized isolator and earth switch also can be manually operated when the parallel

circuit is energized.

3.19.5 MAIN CONTACTS

All Isolators shall have heavy duty, self-aligning and high-pressure line type **dust-free jaw** contacts made of high conductivity, corrosion resistant, hard-drawn electrolytic copper strips of proper thickness and contact area. Fixed contact should consist of loops of above copper strips suitable for 4000 Amps, 1600 Amps, 1250 Amps, and 1250Amps ratings for 400kV, 220 KV, 132KV and 33KV Isolators respectively. The hard dawn electrolytic copper strips should be silver plated 25micron thickness and fixed contacts should be backed by powerful phosphor bronze/stainless steel springs of suitable numbers. The main contacts should be preferably of tulip type design. However, the thickness and contact area of the contact should conform to the drawing approved during type test. Moving contact with moving arm should be of hard- drawn electrolytic copper of proper thickness and contact area.

These fixed and moving contacts shall be able to carry the rated current continuously and the maximum fault current of 63/50/40/31.5 KA for 400/220/132/33KV respectively for **1 seconds** without any appreciable rise in temperature. The Isolator blades shall retain their form and straightness under all conditions of operation including all mechanical stress arising out of operation as well as under rated short circuit condition.

Fixed guides shall be provided so that even when the blades are out of alignment, closing of the switches, proper seating of the blades in between contacts and adequate pressure to give enough contact surface is ensured. The contact shall be self-cleaning by the wiping action created by the movements of the blades.

The Isolator shall be self-cleaning type so that when isolators remain closed for long periods in a heavily polluted atmosphere, binding does not occur. No undue wear or scuffing shall be evident during the mechanical endurance tests, contacts and springs shall be designed so that adjustment of contact pressure shall not be necessary throughout the life of the isolator. Each contact or part of contacts shall be independently sprung so that full pressure is maintained on all contact at all times.

3.19.6 ARCING HORN AND GRADING HORN

Suitable arcing horn made of tinned electrolytic copper which are required for guiding contacts shall be provided on the fixed and moving contacts of all Isolators. The contacts shall be of 'make before and break after" type. Aluminium alloy grading ring are to be provided for 220kV and above voltage level.

3.19.7 ELECTRICAL INTERLOCK / MECHANICAL INTERLOCK

The disconnecting switches whenever required shall be with an approved type electrical interlock for interlocking with the associated circuit breakers and earth switch.

Electrical interlock shall ensure reliable operation. The design should be such that the electrical circuit for the interlocking mechanism **will remain energised as per operation of the isolator with integrated earth switches.**

3.19.8 AUXILIARY SWITCHES

All isolators and earthing switches shall be provided with 220VDC auxiliary switches for their remote position indication on the control board and for electrical locking with other equipment. The auxiliary switch shall be provided with a minimum of six auxiliary contacts- 10 normally open and 10 normally closed and 10 normally open and 10 normally closed for earth switch. Separate auxiliary switches shall be provided for isolating and earth switches. 6 additional NO and NC contact to be provided as spare in each case.

The auxiliary switches and auxiliary circuits shall have a continuous current carrying capacity of at least 10 Amps. Auxiliary switches shall not be used as limit switches. Details of make, rating and type of limit switch shall be furnished in the offer.

3.19.9 EARTH SWITCH

Line earth switch shall consist of three earthing blades for Isolator which normally rest against the frame when the connected Isolator is in closed position. The earthing blades for three phases shall be mechanically linked to a coupling shaft which shall be capable of being fitted on either side of the Isolator. The earthing blades shall match and be similar to the main switch blades and shall be provided at the hinge; with suitable flexible conductors with terminal lugs for connecting to the station ground bus. The earthing blades shall be operated by a separate mechanism but shall be mechanically interlocked with the main switch so that the earthing blades can be closed only when the main switches are in open position and vice-versa. The earthing blades shall be gang operated and all the three blades will operate simultaneously.

3.19.10 OPERATING MECHANISM

The operating mechanism shall be simple and shall ensure quick and effective **10000** mechanical operation. The design shall be such as to enable one man to operate it with nominal effort. The operating mechanism box shall be made out of aluminium extruded (Aluminium alloy) sections of minimum 3.0 mm thickness. The operating mechanism shall be strong rigid and not subject to rebound.

The Isolator blades shall be in positive continuous control throughout the entire cycles of operation. The operating rods and pipes shall be rigid enough to maintain positive control under most adverse conditions and to withstand all torsional and bending stresses arising from operation. Operation of the switches at any speed should not result in improper functioning, in displacement of parts / machines after final adjustment has been made. All holes in cranks, linkages etc. having moving pins shall be fitted accurately so as to prevent slackness and lost motion.

Provision shall be made for padlocking the operating mechanism of disconnecting and earth switches in both open and closed positions.

Bearings shall be ball and roller type shall be protected from weather and dust by means of cover and grease retainers. Bearings pressures shall be kept low to ensure long life and care of operation.

Each power operated isolator shall be motor driven as well as manually operated and shall be complete with local / remote selector switch and open /close push buttons.

Provision shall be made in the control cabinet to disconnect power supply to prevent local / remote power operation. **Limit switches shall be provided with required number of contacts for isolators and earth switches.**

All the terminal blocks to be used in the operating mechanism should of **Ring type** of Poly-amide/Melamine material of make like Elmex/Connectwell.

3.19.11 DESIGN, MATERIALS AND WORKMANSHIP

The live parts shall be designed to eliminate sharp points, edges and corona producing surfaces. Where this is impracticable, adequate shields to be provided. All ferrous metal parts shall be hot dip galvanized, as per IS 2629.All metal parts shall be of such materials or treated in such a way so as to avoid rust, corrosion and deterioration due to continued exposure to atmosphere and rain. All current carrying parts shall be made from high conductivity electrolytic copper .

Bolts, screws and pins shall be provided with standard locking device viz. Locknuts, spring washers, keys etc. and when used with current carrying parts, they shall be made of copper silicon or other high conductivity and wear resistant alloys.

The **isolators** should not need lubrication of any parts except at very long interval of five year minimum.

3.19.12 PROTECTIVE COATINGS

All ferrous parts including bolts, nuts and washers of the switches assembly shall be galvanized to withstand at least six one minute dips in copper sulphate solution of requisite strength (Prece tests) except the threaded portions which should withstand four dips.

3.19.13 INSULATORS

Support insulators for all type of isolators shall be of solid core type. The insulator shall be made of homogeneous and vitreous porcelain of high mechanical and dielectric strength. It shall have sufficient mechanical strength to sustain electrical and mechanical loading on account of wind load, short circuit, **seismic** forces etc. Glazing of the porcelains shall be of uniform dark brown colour with a smooth surface arranged to shed away raise water. The porcelain shall be free from laminations and other flaws or imperfections that might affect the mechanical or dielectric quality. It shall be thoroughly vitrified, tough and impervious to moisture. The porcelain and metal ports shall be assembled in such a manner and with such material that any thermal differential expansion between the metal and porcelain parts throughout the range of temperature specified in this specification shall not loosen the parts or create under internal stresses which may affect the mechanical or electrical strength or rigidity. The assembly shall not have excessive concentration of electrical stresses in any section or across leakage surfaces. The cement used shall not give rise to chemical reaction with metal fittings. The insulator shall be suitable for water washing by rain or artificial means in service condition. Profile of the insulator shall also conform to IEC-815. Caps to be provided on top of the insulator shall be of high-grade cast iron or malleable steel casting. It shall be machine faced and hot dip galvanized. The cap shall have four numbers of tapped holes spaced on a pitch circle diameter of 127mm. The holes shall be suitable for bolts with threads having anti corrosive protection. The effective depth of threads shall not be less than the nominal diameter of the bolt. The cap shall be so designed that it shall be free from visible corona and shall have radio interference level **as specified in table of Clause 10.0** of Casing shall be free from blow holes cracks and such other defects.

3.19.14 CONTROL CABINET:

The control cabinet of the operating mechanism shall be made out of minimum 3mm thick aluminium alloy sheet. Hinged door shall be provided with pad locking arrangement. Sloping rain hood shall be provided to cover all sides. 15 mm thick neoprene or better type of gaskets shall be provided to ensure degree of protections of at least IP 55 as per IS 2147/IS-3947. The cabinet shall be suitable for mounting on support structure with adjustment for vertical, horizontal and longitudinal alignment. Details of these arrangements shall be furnished along with the offer.

3.19.15 MOTOR:

Motors rated 0.5 KW and above shall be **provided with** suitable for operation on 3 phase, 415 V, 50 Hz supply. Motors of lower rating shall be single phase type suitable for 240V, 50Hz system. It shall be totally enclosed type if mounted outside the control cabinet. The motor shall withstand without damage stalled torque for at least 3 times the time lag of the tripping device. The motor shall, in all other respects, conform to the requirement of I.S. 325**. Suitable relay/device shall be provided to prevent over loading of the motor. Single phase preventer (for 3 phase meter) shall be provided to operate on open circuiting of any phase and shall trip off the motor. Complete details of the devices shall be furnished in the offer.**

3.19.16 GEAR:

The dis-connector / isolator may be required to operate occasionally, with considerably long idle intervals. Special care shall be taken for selection of material for gear and lubrication of gears to meet this requirement. The gear shall be made out of aluminium bronze or any other better material lubricated for life with graphite or better-quality non-drawing and non-hardening type grease. Wherever necessary automatic relieving mechanism shall be provided.

3.19.17 SPACE HEATERS:

Space heaters suitable for 1 phase 240V AC supply shall be provided for each motor operated operating mechanism to prevent condensation and shall be operated by MCB.

3.19.18 TERMINAL BLOCK AND WIRINGS

Each operating mechanism shall be provided with 1100V grade **ring** type terminal block. All auxiliary switches, **spare contact of the contactors**, interlocks and other terminals shall be wired up to terminal block. The terminal block shall have at least 20% extra terminals. All wiring shall be carried out with 1.1KV grade **PVC** insulated 2.5 sq.mm. copper wires.

3.19.19 INTERIOR ILLUMINATION:

A holder suitable for a 240 V lamp shall be provided in each of the motor operated mechanism of three poles & shall be door operated type.

3.19.20 CONTROL AND AUXILIARY SUPPLY:

A 3-phase switch with MCB for phases and link for neutral, shall be provided for power supply and a 2 pole MCB shall be provided for control supply.

3.19.21 POSITION INDICATOR:

A position indicator to show the isolator is in ON or OFF position to be provided.

3.19.22 NAME PLATE:

Isolator, earthing switches and their operating devices shall be provided with name plate. The name plate shall be weatherproof and corrosion proof. It shall be mounted in such a position that it shall be visible in the position of normal service and installation. It shall carry the following informations duly engraved or punched on it.

A. Isolator Base

Name: AEGCL
Name of manufacturer –

Order No. –

Type Designation –

Manufacturers serial No. –

Rated voltage –

Rated normal current –

Rated short time current (rms) and duration –

Rated short time peak current (KAP)

Weight-

Manufacturing Statndard-

B. **Earthing Switch**

Name: AEGCL

Name of manufacturer –

Order No. –

Type Designation –

Manufacturers serial No. –

Rated voltage –

Rated normal current –

Rated short time current (rms) and duration

Rated short time peak current (KAP)

Weight

C. Operating Device
Name – AEGCL

Name of manufacturer –

Order No.

Type Designation –

Reduction gear ratio –

AC motor

i) Rated auxiliary voltage

ii) Starting current

iii) Designation of AC motor as per IS 4722/325

iv) Starting torque at 80% of supply voltage

v) Over travel in degrees after cutting off supply

Total operating time in seconds

i) Close operation – Electrical

ii) Open operation – electrical

iii) Open operation – manual

3.19.23 PAINTING GALVANIZING AND CLIMATE PROOFING:

At interiors and exteriors of enclosures, cabinets and other metal parts (other than made up of aluminium) shall be thoroughly cleaned to remove all rust, scales, corrosion, grease and other adhering foreign matter and the surfaces treated by phosphating (e.g. seven tank phosphating sequence). After such preparation of surfaces, two coats of zinc oxide primer shall be given by suitable stoving and air drying before final painting **with epoxy paint.** Colour of the final paints shall be of shade no. 697 of IS:5. The finally painted cubicle shall present aesthetically pleasing appearance free from any dent or uneven surface.

Paint inside the metallic housing shall be of anti-condensation type and the paint on outside surfaces shall be suitable for outdoor installation.

All components shall be given adequate treatment of climate proofing as per IS:3202 so as to withstand corrosive and severe service conditions.

All metal parts not suitable for painting such as structural steel, pipes, rods, levers, linkages, nuts and bolts used in other than current path etc. shall be hot dip galvanized as per IS –2629. Galvanization test will be carried out during routine test.

Complete details of painting, galvanizing and climate proofing of the equipment shall be furnished in the offer.

3.19.24 TESTS:

Type Tests:

Isolators offered, shall be fully type tested as per the relevant standards. The Bidder shall furnish Three sets of the following valid type test reports for their different type of offered Isolators along with the offer. The AEGCL reserves the right to demand repetition of some or all the type tests in the presence of AEGCL's representative. For this purpose, the Bidder may quote unit rates for carrying out each type test and this will be taken during bid price evaluation, if required.

a) Short time withstand & peak withstand current test for Isolator & Earth Switch.
b) Power frequency (Dry & Wet), Lightening Impulse dry withstand Test
c) Mechanical endurance Test
d) IP-55 test
e) Seismic test
f) Temperature Rise test

During type tests the isolator shall be mounted on its own support structure or equivalent support structure and installed with its own operating mechanism to make the type tests representative. Drawing of equivalent support structure and mounting arrangements shall be furnished for Purchaser's approval before conducting the type tests.

The type tests shall be conducted on the isolator along with approved insulators and terminal connectors. Mechanical endurance test shall be conducted on the main switch as well as earth switch of one isolator of each type.

Acceptance and Routine Test:

All acceptance and routine test as stipulated in the relevant standards shall be carried out by the supplier in presence of Purchaser's representative.

Mechanical operation test (routine test) shall be conducted on isolator (main switch and earth switch) at the supplier's works as well as purchaser's substation site.

Immediately after finalization of the programme of type / acceptance, routine testing the supplier shall give sufficient advance intimation (clear 20 days advance intimation), along with shop routine test certificates, valid calibration reports from Govt. approved **(NABL)** test house for the equipment, instruments to be used during testing for scrutiny by the AEGCL to enable him to depute his representative for witnessing the tests. If there will be any discrepancies in the shop routine test certificates and calibration reports furnished by the firm then after settlement of the discrepancies only, purchaser's representative will be deputed for witnessing the tests. Special tests proposed to be conducted (if decided to conduct) as type test on isolators, are given at Annexure- II. Thesespecial type test charges shall be quoted along with all other type tests as per relevant IEC standard and these charges shall be included in the total bid price

Test certificates of various items including but not limited to the following shall be furnished at the time of routine tests.

a) Chemical analysis of copper along with a copy of excise certificate indicating genuine source of procurement of electrolytic grade copper.

b) Bearings

c) Fasteners

d) Universal / swivel joint coupling

e) Insulators

f) Motor

g) Gears

h) Auxillary switch

i) Limit switch

j) Timer

k) Overload / single phase preventer relay

l) Interlocking devices

m) Terminal block

n) Any other item

3.19.25 INSPECTION:

i) The Purchaser shall have access at all times to the works and all other places of manufacture, where the disconnectors, earth switches and associated equipment are being manufactured and the supplier shall provide all facilities for unrestricted inspection of the works raw materials manufacture of all the accessories and for conducting necessary tests as detailed herein.

ii) The supplier shall keep the purchaser informed in advance of the time of starting of the progress of manufacture of equipment in its various stages so that arrangements could be made for inspection.

iii) No material shall be dispatched from its point of manufacture unless the material has been satisfactorily inspected and tested.

iv) The acceptance of any quantity of the equipment shall in no way relieve the supplier of his responsibility for meeting all the requirements of this specification and shall not prevent subsequent rejection if such equipment is later found to be defective.

3.19.26 QUALITY ASSURANCE PLAN:

The Bidder shall invariably furnish following information along with his offer, failing which his offer shall be liable for rejection.

(i) Names of sub suppliers for raw materials, list of standards according to which the raw materials are tested, list of tests normally carried out on raw materials in presence of Supplier's representative, copies of test certificate

(ii) Information and copies of test certificates as in (i) and (ii) above in respect of bought out accessories.

(iii) List of manufacturing facilities available

(iv) Level of automation achieved and lists of areas where manual processing still exists.

(v) List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.

(vi) List of testing equipment with calibration certificates from Govt. approved**(NABL)** test house available with supplier for final testing equipment and test plant limitation if any, vis-à-vis the type, special acceptance and routine test specified in the relevant standards. These limitations shall be very clearly brought out in the specified test requirements.

(vii) QAP shall include acceptance criteria mentioning clause no. of applicable standard against each parameter.

The supplier shall within 30 days of placement of order, submit following information to the purchaser.

i) List of raw material as well as bought out accessories and the names of sub-suppliers selected from the lists furnished along with offer.

ii) Type test certificates of the raw material and both bought out accessories.

iii) Quality Assurance Plan (QAP) withhold points for purchaser's inspection.

The supplier shall submit the routine test certificates of bought out accessories and raw material viz. Copper, aluminum conductors, lubricating material, gear material etc. at the time of routine testing of the fully assembled isolator.

3.19.27 DOCUMENTATION:

All drawings shall conform to relevant international standards organization (ISO).. All dimensions and data shall be in S.I. Units.

List of Drawings and Documents

The Bidder shall furnish **four** sets of following drawings / documents along with his offer.

a) General outline and assembly drawings of the dis-connector operating mechanism, structure, insulator and terminal connector.

b) Sectional views and descriptive details of items such as moving blades, contacts, arms contact pressure, contact support bearing housing of bearings, balancing of heights, phase coupling pipes, base plate, operating shaft, guides, swivel joint operating mechanism and its components etc.

c) Loading diagram

d) Drawings with structure for the purpose of type tests.

e) Name plate.

f) Schematic drawing.

g) Type test reports.

h) Test reports, literature, pamphlets of the bought-out items and raw material.

i) Deviation sheet/compliance sheet if applicable

Six sets of the type test report, duly approved by the Purchaser shall be submitted by the supplier for distribution, before commencement of supply Adequate copies of acceptance and routine test certificates, duly approved by the Purchaser shall accompany the dispatched consignment.

The manufacturing of the equipment shall be strictly in accordance with the approved drawings and no deviation shall be permitted without the written approval of the purchaser. All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawing shall be at the supplier risk.

The supplier shall within 2 weeks of placement of order submit four sets of final versions of all the above said drawings for AEGCL's approval. The purchaser shall communicate his comments / approval on the drawings to the supplier. The supplier shall, if necessary, modify the drawings and resubmit four copies of the modified drawings for AEGCL's approval within two weeks from the date of comments.

3.19.28 INSTRUCTION MANUALS:

Fifteen copies of the erection, operation and maintenance manuals in English to be supplied for each type of disconnector one month prior to dispatch of the equipment. The manual shall be bound volumes and shall contain all drawings and information required for erection, operation and maintenance of the disconnector including but not limited to the following particulars.

(a) Marked erection prints identifying the component parts of the disconnector as shipped with assembly drawings.

(b) Detailed dimensions and description of all auxiliaries.

(c) Detailed views of the insulator stacks, metallics, operating mechanism, structure, interlocks, spare parts etc.

3.19.29 PACKING AND FORWARDING:

The equipment shall be packed in crates suitable for vertical / horizontal transport, as the case may be and suitable to withstand handling during transport and outdoor storage during transit. The supplier shall be responsible for any damage to the equipment during transit, due to improper and inadequate packing. The easily damageable material shall be carefully packed and marked with the appropriate caution symbols.

Wherever necessary, proper arrangement for lifting, such as lifting hooks etc. shall be provided. Any material found short inside the packing cases shall be supplied by supplier without any extra cost.

Each consignment shall be accompanied by a detailed packing list containing the following information:

(a) Name of the consignee.

(b) Details of consignment.

(c) Destination.

(d) Total weight of consignment.

(e) Handling and unpacking instructions.

(f) Bill of material indicating contents of each package.

The supplier shall ensure that the bill of material is approved by the purchaser before dispatch.

3.19.30 SUPERVISION OF ERECTION TESTING AND COMMISSIONING (ET&C):

Purchaser proposes to utilize the services of the supplier for supervision of testing and commissioning of the equipment being supplied by him, if it is required. For this purpose, the supplier should make available the services of trained personnel (Engineers) who shall correct in the field, any errors or omissions in order to make the equipment and material properly perform in accordance with the intent of this specification. The Engineer shall also instruct the plant operators in the operation and maintenance of the commissioned equipment. The supplier shall be responsible for any damage to the equipment on commissioning the same, if such damage results for the faulty or improper ET&C. Purchaser shall provide adequate number of skilled / semi-skilled workers as well as ordinary tools and equipment and cranes required for equipment erection, at his own expenses. Apart from the above, the Purchaser shall not be responsible for providing any other facilities to the supplier. Special tools if required for erection and commissioning shall be arranged by the supplier at his cost and on commissioning these shall be supplied to the purchaser free of cost for future use.

APPENDIX – I

(Isolators)

LIST OF SPECIAL TESTS TO BE CARRIED OUT IF DECIDED BY THE PURCHASER

Sl. No.	Name of the Test	Standard to which it conforms.
1.	Test for visible Corona and Radio interference voltage (RIV) on disconnectors and terminal connector	NEMA Pub No. 107-1964 ISRI Pub No. 1-1972
2.	Tests on insulators	IS-2544 IEC. 168
3.	Tests on terminal connectors	IS:5561
4.	Tests on galvanized components	IS:2633
5.	Stalled torque test on motor operating mechanism	At 110% of supply voltage

CHAPTER 3.20: TECHNICAL SPECIFICATION FOR XLPE CABLE WITH TERMINATION

TECHNICAL SPECIFICATION OF 33kV, 66KV, 132KV, 220KV & 400KV XLPE CABLE AND TERMINATION

3.20.1 SCOPE

The specification covers Design, Engineering, Construction, Supply & Delivery, Erection, Laying, Testing & Commissioning including Transportation & Insurance, Storage of XLPE Cable of different ratings and their associated works.

3.20.2 STANDARD & CODES

The works covered by the specification shall be designed, engineered, manufactured, tested and commissioned in accordance with the Standards as specified in the table below.

Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards referred shall also be accepted. Copies of such standards shall be submitted by the bidder along with the bid.

IS 7098 : Part 3 : 1993	Cross-linked polyethylene insulated thermoplastic sheathed cables: For working voltage from 66KV up to and including 220KV.
IS 8130 : 1984	Conductors for insulated electric cables and flexible cords
IS 5831 : 1984	PVC insulation and sheath of electric cables.
IS 1255 : 1983	Code of practice for installation and maintenance of power cables upto and including 33KV rating.
IS 3975 : 1999	Mild steel wires, formed wires and tapes for armouring of cables.
IS 5831 : 1984	PVC insulation and sheath of electric cables.
IS 6380 : 1984	Elastomeric insulation and sheath of electric cables.
IS 8130 : 1984	Conductors for insulated electric cables and flexible cords.
IS10418 : 1982	Drums for electric cables
IS 5 : 1994	Colours for ready mixed paints and enamels.
IS 617 : 1994	Aluminum and aluminium alloy ingots and castings for general engineering purposes (Superseded IS 20: 1977)
IS 3043 : 1987	Code of practice for earthing.
IS 5578 : 1984	Guide for marking of insulated conductors.
IS 11353 : 1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals.
IS 5216 : Part I : 1982	Recommendations on Safety Procedures and Practices in Electrical Work.
IS 2071 : 1993	High voltage test techniques.
IEC-60540	Power cables with extruded insulation and their accessories and cords
EC 60060 : 1989	High Voltage Test Techniques
IEC-60502	Extruded solid dielectric insulated power cables for rated voltages from 1KV up to 30KV
IEC-60754 : 1991	Tests on gases evolved during combustion of electric cables
IEC-60183 : 1990	Guide to the Selection of High Voltage Cables.
IEC-60230 : 1996	Impulse tests on cables and their accessories.
IEC-60840 / IEC- 62067	Testing
IEC-60287 : 1995	Calculation of the continuous current rating of cables (100%load factor).
IEC-60304 : 1982	Standard colours for insulation for low-frequency cable and wires
IEC-60331 : 1970	Fire resisting characteristics of Electric cables.
IEC-60332 : 1992	Tests on electric cables under fire conditions.
BS-5468	Cross-linked polyethylene insulation of electric cables
IEC-60228 : 1978	Conductors of insulated cables

IEC-60332 : 1993	Test on electric cables under fire conditions
IEC-60066	Environmental Test
IEC-60117	Graphical Symbols
IEC-60270 : 2000	Partial Discharge Measurements
CSA-Z299.1-1978h	Quality Assurance Program Requirements
CSA-Z299.2-1979h	Quality Control Program Requirements
CSA-Z299.3-1979h	Quality Verification Program Requirements
CSA-Z299.4-1979h	Inspection Program Requirements
ASTMD-2863	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)

3.20.3 COMPLIANCE TO SPECIFICATION & DEVIATION:

Normally the offer should be as per Technical Specification without any deviation. But any deviation felt necessary to improve performance, efficiency and utility of equipment must be mentioned in the Deviation Schedule with reasons duly supported by documentary evidence. Such deviations suggested may or may not be accepted by the purchaser.

As a mark of technical conformance, all sheets of the specification shall be furnished by each bidder with the signature and company seal affixed thereon. In case of any deviations, the same shall be carried out in the deviation schedule only. Deviations not mentioned in Deviation schedule will not be considered.

The bidder shall also submit the GTP as per Annexure-1 duly signed with date & company seal for acceptance of the Technical Bid unless which the bid may be considered as non-responsive.

3.20.4 CONSTRUCTION

1. **For 66KV and above**: The cable shall be of applicable EHV grade as per requirement according to price schedule, single core, armored, stranded compacted circular Copper conductor in case of cross section less than or equals to 800 sq.mm or segmental compacted circular (Miliken) Copper conductor in case of cross section over 800 sq.mm, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, crosslinked polyethylene (XLPE) tree- retardant/ super clean dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non woven tape with water swellable absorbent over insulation screen, followed by radial sealing of corrugated & seamless aluminum& overall HDPE sheathed (conforming to IEC 60840/ IS 7098 Part III)& graphite coated and conforming to the technical particulars of specification.

   For 33KV : Untinned annealed copper conductor of class 2 as per IS 8130/1984 and any latest amendments to it. The shape of conductor shall be compacted, stranded, and circular/ sector shaped, shielded with conductor screen of black extruded semi-conducting compound , XLPE insulation, shielded with insulation screen of black extruded semi- conducting compound, black semi-conducting tape and metallic screen of copper tape, Inner sheath extruded PVC type ST2, single layer of strip/ round steel, round hard drawn aluminium wire armoured and black extruded FR-PVC (TypeST-2) overall sheathed, conforming generally to IS:7098 (PartII

3.20.5 COMPOSITIONS OF CABLES

3.20.5.1 CONDUCTOR

For the cable sizes having cross section over 800 sq.mm, the segmental compacted circular conductor having minimum four (4) segments should be constructed for the supply under the scope of bid. When the conductor's cross-section is less than 400 sq.mm, the compacted circular is applied generally.

3.20.5.2 CONDUCTOR SCREEN

The conductor screen shall consist of extruded semi-conducting XLPE. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor XLPE.

3.20.5.3 INSULATION

The insulation material shall be extruded cross-linked polyethylene for 33kV and tree- retardant/ super clean XLPE for 66kV and above.. In order to ensure that the screen and insulation are intimately bonded together and free from all possibilities of voids between layers, the conductor screen, the insulation and the insulation screen should be extruded simultaneously in one process in single cross-head. The extrusion process should be carried out under strictly controlled atmospheric conditions.

The thickness of the insulation layer should be maintained as the maximum value figured out from the design of the impulse voltage and A.C. voltage. The cross-linking process by N2 gas should be preferred instead of conventional cross-linking process by saturated steam

3.20.5.4 INSULATION SCREEN

The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE.

3.20.5.5 MOISTURE BARRIER

The longitudinal water barrier shall be applied over insulation screen by a layer of non woven synthetic tape with suitable water swellable absorbent.

3.20.5.6 METALLIC SCREEN:

The metallic screen shall be of copper wire or corrugated aluminium as per IS. The metallic screen shall be designed to meet the requirement of the system short circuit rating of 31.5KA for 3 sec (for 33KV and 66KV), 40KA for 3Sec (for 132KV) and 50KA for 3 sec (for 220KV). Copper wire screening may be used if required to meet the above ratings.

ARMOURING (FOR 33KV CABLE)

3.20.5.7 The armoring shall be of non-magnetic material.

3.20.5.8 Armoring shall be applied over the insulation or protective barrier or non-metallic part of insulation screening, in case of single core cables or inner sheath in case of screened and armoured single core cables.

c) The armour wires/strips shall be applied as closely as practicable the direction of lay of the armour shall be left hand. For double wires/strips armoured cables, this requirement shall apply to the inner layer of wires/strips. The outer layer shall, except in special cases, be applied in the reverse direction to the inner layer, and there shall be a separator of suitable non-hygroscopic material; such as plastic tape, bituminized cotton tape, bituminized hessian tape, rubber tape, proofed tape between the inner and outer layers of armour wires strips.

d) A binder tape may be applied on the armour.

e) The joints in armour wires of strips shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire/strip shall be at least 300 mm from the nearest joint in any other armour wire/strip in the completed cable, Number of joint in a single wire to be limited.

3.20.5.9 OUTER SHEATH

The outer sheath shall consist of Extruded black HDPE (TypeST7) grade. The outer sheath shall be designed for protection against termite and rodent attack and shall be coated with graphite.

3.20.6 RATING

A complete set of calculation made in arriving at the current rating shall be furnished for laying condition and cable sheath bonding system adopted. Short circuit temperature shall be limited to 250 degree C.

3.20.7 CABLE DRUMS

Cables shall be supplied in wooden or steel drums of heavy construction of suitable size and packed conforming to IS 10418 or applicable internationally accepted standards. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum. A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

Each drum shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stenciled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. A narrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with hermetically sealed by means of water blocking compound followed by heat shrinkable caps totally coated inside with mastic so as to prevent to cable for moisture penetration during transit, storage and laying.

The bidder shall consider supply of cable on returnable drums basis. Contractor shall take back all the cable drums from site after successful laying, testing and commissioning of cables. If any length of cable remains unused, the same shall be adjusted by the employer.

Embossing of outer sheet: the following details on the other sheet of cable at a regular interval of 1(one) meter.

(a) Name of Customer i.e. AEGCL

(b) Conductor size, type of insulation and voltage grade.

(c) Manufacturer's name.

(d) Year of manufacturing

3. 20.8 TESTS

All routine and acceptance tests shall be conducted as per IEC60840/IEC62067. All type tests conducted during last five years from the date of NIT as per IEC 60840:1999/ IEC 62067:2001 including its amendments on the XLPE insulated HT cable should be submitted. The diameter of test cylinder during bending test shall be as per IS:7098 (Part3) or the diameter of drum barrel to be used for dispatch of cables which ever is lower. For accessories type test reports should be submitted as per Clause 11.3.2 IEC 60840:1999/ Clause12.4.2 IEC62067:2001 & including amendments.

Following additional type tests shall be carried out on outer sheath of XLPE insulated HT cable.

a. Oxygen index and temperature index test as per ASTMD-2863.
b. Chemical composition test for verifying lead sheath composition.

All tests as prescribed in IEC-60840 shall be performed after installation of cable.

TESTS AFTER INSTALLATION

All tests as prescribed in IEC-60840:1999/IEC 62067:2001 shall be performed after installation of cable.

3.20.9 TRENCHING

The cable trench work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be left as clean as possible.

The trench shall be excavated using manual/ mechanical modes as per field conditions.

Where paved foot paths are encountered, the pavements labs shall be properly stored and reinstated. Identification markers of other services shall be properly stored and restored.

The sides of the excavated trenches shall wherever required be well shored up.

Suitable barriers should be erected between the cable trench and pedestrian/motor way to prevent accidents. The barriers shall be painted with yellow and black or red and white coloured cross stripes. Warning and caution boards should be consciously displayed. Red lights as warning signal should be placed along the trench during the nights.

The excavated material shall be properly stored to avoid obstruction to public and traffic movement.

The bottom of the excavated trench should be levelled flat and from any object which would damage the cable. Any gradient encountered shall be gradual.

3.20.10 LAYING OUT

The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before laying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out of uniform intervals. The laying out process must be smooth and steady without subjecting the cable to abnormal tension. The cable on being laid out shall be smoothly and evenly transferred to the ground after providing the cushion. The cables shall never be dropped. All snake bends shall be straightened. Suitable size cable stocking pulling eye shall be used for pulling the cable. While pulling the cable by winches or machines, the tension loading shall be by tension indicator and shall not exceed the permissible value for the approved cable pulling tension calculation.

The cable end seal shall be checked after laying and if found damaged shall immediately be resealed. Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work. The integrity of the outer sheath shall be checked after the cable is laid in position.

3.20.11 LAYING OF CABLES

The installation, testing and commissioning work for laying of cable in the entire route within the substation, through the outside cable laying corridor as per designated approved route shall mainly consist of:

a) Route survey for the entire route length under the scope of work. This is also to finalize drum wise cable length with their tolerances.
b) Clearances from relevant authorities for lying of cables.
c) Formation of buried cable trenches for cables as per specification including supply and installation of warning tape, protective tiles / brick layer of minimum class designation 50 (50kg./sq.cm.) cable protection covers for entire route, construction of jointing bays, back filling of trenches and restoration as per specification.
d) Road crossings shall be through HDPE pipe embedded in concrete duct for each cable and restoration as

per specification. Rail and canal crossings shall be through direct drilling with steel drum.

e) Cable markers as per statutory requirements shall be provided all along the route at a maximum distance of 500 meters and other important locations. Also the location of underground cable shall be clearly indicated on the marker.

f) Supply and installation of straight through joints for complete route.

g) Design, supply and installation of suitable hangers and other necessary structures for running the cable at over head road bridge.

h) Supply and installation of all critical installation materials like trefoil clamps, neoprene cushions, support brackets etc. as required for complete route to avoid damages of the cable. Neoprene cushion shall be provided at road and rail bridge crossings to avoid damage of cable due to vibrations during movement of trains and vehicles.

i) Termination of cables, bonding of screen/sheath to the earth station through disconnecting type link boxes and SVL (sheath voltage limiter) at cable conductor junction-point etc. Bidder shall adopt cable sheath bonding for route under scope as per detailed Engineering calculation in line with IEEE 575. Earthing stations/ Earthing pits, earthing materials and earthing conductors wherever applicable for complete route including outdoor equipment, structure, cable terminating structure and earth link box at the locations mentioned above shall be in contractors' scope.

j) Design, fabrication, supply and erection of galvanized steel structures (including its civil foundation) for cable end terminations (with all necessary accessories) for cable sat cable–conductor junction point. At cable-conductor junction point terminal connectors offered by bidder shall be suitable to terminate with ACSR conductors.

k) For termination at GIS substation end the cable should be laid up to GIS module inside the GIS building. Necessary design construction of cable duct/ trench/ cellar etc. in the GIS Sub-Station including all supply is within the scope of this contract.

l) Design, supply and installation of LA sat cable–conductor junction point for both the circuits including its mounting structure and Las & Isolator sat Sub-Station.

m) Termination, bonding, earthing etc. at GIS sub-station end is not within the scope of this work.

n) All EHV cable routes shall be provided with one linear heat sensing cable to detect any fire and provide alarm.

3.20.12 LAYING OVER PRE-CONSTRUCTED TRENCH

For laying of the cable on a pre-constructed trench below the road in any planned township area, Bridge, switchyards etc., cable shall have to be accommodated in the space allotted in the trench for laying the cables. Sufficient clamping arrangement shall be done for fixing the cable properly. Cables may be placed in trefoil arrangements as per allotted width of the trench. The clearances between the cable trays shall be minimum 330mm for cables up to 132kV and 400mm for cables of 220kV and 400kV. For 66kV cables, maximum two bends are allowed in 20 mtr span and for 132kV, 220kV and 400kV cables, not more than one bend shall be provided in 20 mtr span. Any damages occurred in the trench during lay of the cable shall have to be repaired properly. Wherever there is crossing with any utility line, the utility line will cross the cable route/ jointing bays at minimum separation distance of 500mm below cable route/ jointing bays.

3.20.13 CLAMPS

Clamps shall be pressure die cast aluminium (LM-6) or Nylon-6 or fiber glass and shall include neoprene rubber lining wherever the cable touches the clamps and below the clamp base and necessary fixing non magnetic nuts, bolts, washer etc. The thickness of neoprene rubber shall not be less than 10 mm inside around the inner surface of the trefoil clamp and minimum 20 mm thick below the base of trefoil clamp. The neoprene shall be tested as per ISIII49-1984. Clamps shall be provided at every one meter of cable runs. The contractor shall submit drawings of trefoil clamps and arrangements for Employer approval.

Self supported Aluminium Spring load clamp shall be provided for Cable termination structure at every 1 metre of cable run. The contractor shall submit the drawings of spring load clamp for employer's approval.

3.20.14 CABLE HANDLING

The inspection of cable on receipt, handling of cables, laying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surface, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in general conform to IS1255- 1983 or its equivalent.

CABLE JOINTING BAYS

Cable jointing bays shall be provided for single core EHV cables in a staggered manner along the cable route with adequate space for bonding of sheaths and link boxes as well as for testing. The jointing bays shall have adequate number of cable ducts entry and exits including spare ducts with fire seals. The jointing bays shall have chequered covers of minimum 6mm thickness

DAMAGE TO PROPERTY

The contractor shall take all precautions while excavation of trench, trial pits etc., to protect the public and private properties and to avoid accidental damage. Any damages caused shall be immediately repaired and brought to the notice of the concerned and to the Employer.

- The contractor shall bear all responsibilities and liabilities and shall bear all costs of the damages so caused by him or by his workman or agents.
- At places where the cables cross private roads, gates of residential houses or buildings, the cables shall be laid in HDPE pipes of adequate strength using HDD technology.

3. 20.15 CABLE ROUTE MARKERS / CABLE JOINT MARKERS

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per drawings approved by AEGCL.

Cable markers as per statutory requirements shall be provided all along the route at a maximum distance of 30 meters and at all turning points and other important locations.

Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible above ground surface.

The marker should incorporate the relevant information, The name of the owner, voltage, circuit and distance of cable from the marker.

3.20.16 DEPTH OF LAYING OF CABLES

Depth of lay shall be normally at 1.5 m. below ground but variation of depth of lay to1 meter may be considered at the time of detailed engineering on the characteristics of the laying zone.

3.20.17 SAND BEDDING

The cable shall be completely surrounded by well-compacted cables and to such a thickness and of such size that the cable is protected against damage. The thickness of the cable sand should normally be a minimum of 10 cm in all directions from the cable surface.

3.20.18 THERMAL BACK FILL

Based on the evaluation of soil thermal resistivity along the cable route and after approval from the Employer the contractor shall design, specify, supply, lay and monitor the installation of thermal back fill surrounding the cables.

3. 20.19 IMMEDIATE ENVELOPE TO CABLE

The option on the use of the material that immediately envelopes the cable viz., thermal back fill or sand or sieved native soil rests with the Employer. The contractor shall seek prior approval on the use of the envelop material from the Employer before execution of the works.

3. 20.20 BACKFILLING

Normally back filling shall consist of the material earlier excavated. However, bigger stores or pieces of rock should be removed.

3. 20.21 WARNING TAPE

A pre-warning, Red colour plastic/ PVC tape, 250 mm wide100 microns thick, shall be laid at approx. 0.4m above the cable specified depth, throughout the cable route. The tape shall carry the legend printed in black continuously as under

CAUTION: AEGCL ..... KV CABLES.

3.20.22 PREVENTION OF DAMAGE DUE TO SHARP EDGES

After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench.

Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable.

While pulling through pipes and ducts, the cable shall be protected to avoid damage due to sharp edges. The cables shall never be bent, beyond the specified bending radius.

3.20.23 ROAD, RAIL & CANAL CROSSINGS

The road cutting, whether cement concrete asphalt or macadam road surface, rail crossing and canal crossing shall be taken after obtaining approval from the concerned authorities i.e. Railway authorities, irrigation deptt, civic authorities traffic police, telephone authorities etc. and work should be planned to be completed in the shortest possible time. Where necessary, the

work shall be planned during night or light traffic periods. HDPE pipes shall be used for cable. HDPE pipes diameter should not be less than1.5 times the cable diameter.

3.20.24 TRENCHLESS DIGGING

It is envisaged that trenchless digging shall be used for crossing National highways, Rail line and canal and this shall be in the scope of bidder. Trenchless digging shall also be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of underground cables. The trenchless digging methods shall generally conform to ITU-T 1.38. The various methods of trenchless digging such as hand/ manual auguring (upto15m.) impact moulding (from 16m to about 40-50m.).HDD (above40-50m) shall be adopted based on the soil/ site conditions and the requirement and exact method for trenchless digging shall be finalized during detail engineering as per actual site/ soil condition. The equipment used for HDD shall be capable of drilling at least 100m at one go. The contractor shall propose the exact methods and procedures for implementation of trenchless digging at various crossings taking into consideration the following guidelines, for approval by the Employer.

1. Guided boring/drilling technology is to be used.
2. Radio or any detection system should be used for avoiding damage to existing underground utilities.
3. The depth of boring should be such as to clear any underground utilities/obstacles. However in no case the depth of boring shall be less than 1.65m from the road surface.
4. In horizontal and vertical boring, the system should be capable of going up to 10 meter below ground.
5. The span of HDD will be decided in charge as per site requirements.
6. Excavation and back filling of trial pits and verification of soil condition.
7. Excavation of entry and Exit pits.
8. Erection of drill machined. Drilling of pilot hole.
9. Placement and driving hand augur.
10. Placement and carrying out impact moling.
11. Reaming and widening of bore holes in steps (if required).
12. Pulling of product pipe.

3.20.25 FOOTPATH CUTTING

The slabs, curb stones on the roads shall be removed and reinstated without damage. For laying of cables, the specified approved corridor shall be followed below footpath.

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3.20.26 TOOLS AND PLANTS

The successful bidder shall have all necessary tools, plant and equipment to carry out the survey and cable installation work. The bidders are instructed to give all the details of equipment at their disposal to carryout the work successfully and speedily.

3.20.27 BENDING RADIUS:

The minimum bending radius of XLPE insulated cables are as follows :
Cable Bending radius Single Core 25 X D
"D" means the overall diameter of the completed cable.
This bending radius is applicable for direct buried cable route and cable trench.

3.20.28 CABLE END TERMINATIONS & JOINTING

i) The cable jointing accessories shall include the end terminating kits, straight through joints and also any special tools and tackles required for making these joints.

ii) The straight through joints shall be either Pre-molded Heat Shink type complete with all accessories. The joint shall preferably be built up as per the construction of the main cable and shall have electrical and mechanical withstand capabilities same as or better than the main cable. The joints shall be suitable for tropical climatic conditions. All straight through joints and cable terminations shall have field proven experience of minimum five (5) years without any latent design defects.

iii) The outdoor end termination up to 245 KV XLPE Cable shall be Anti-fog, Pre-molded type Silicon Rubber stress cone. Torque controlled mechanical shear head bolted connector with polymeric composite housing (resin cast body with silicon shed housing), dry/fluid filled (silicon oil) type self-supporting with Plug-in / Plug-out facilities. The termination base plate and the cable's metallic sheath shall be electrically insulated from the self supporting structure by means of stand-off epoxy insulators designed to withstand both mechanical and electrical stresses in services. The Polymeric

insulator in grey colour shall be used. In addition upon, arcing horn and shield ring shall have to be supplied as required for 245 & 420 KV XLPE cables. 10%etra silicon oil shall be supplied with termination if fluid filled is supplied.

iv) The outdoor end termination for 400kV shall be based on the Silicon / EPR-based stress relief cone with the epoxy housing and the oil-impregnated cylindrical capacitor cone (so called condenser cone type) to secure the uniform longitudinal voltage distribution all along the termination. Pre-molded type Silicon Rubber sleeve outdoor end termination for 400kV may be offered by the manufacturer if the same is available.

v) The outdoor terminals should be suitable for heavily polluted atmospheric conditions with total creepage distance of 31 mm/ kV and protected creepage distance of not more than 50% of the total creepage distance. The cable end terminals for terminating the cables shall be fully compatible with the cables to be supplied.

vi) The Indoor Termination at GIS SF6 Housing shall be based on the Silicon Rubber based stress relief cone and the epoxy resin housing. There shall be mechanical devices to maintain the interface pressure. Stress relief cone and mechanical devices shall be designed to fit with controlled interference over the cable insulation and shall follow the cable's diameter variations still guaranteeing under any service condition a sufficient positive pressure to control the electric field concentration. There shall be epoxy insulating plate to isolate between cable sheath and GIS chamber. The SVLs (Sheath Voltage Limiter) shall be installed to protect epoxy insulating plate from switching impulse. Plug-in type leading conductors shall be supplied though at the time of detailed engineering confirmation shall be given for selection of plug-in type. Design and scope of delivery shall be fully complying with IEC-60859, IEC-62271-209 and possibly adjusted to various needs of project. The main insulation components shall be fully examined and tested in the factory.

vii) For jointing and terminations, one qualified Engineer and required trained EHV jointers with supporting staff should be deputed. The engineer and EHV jointers shall posses valid certificate from the manufacturer of the Accessories, for erection.

viii) The detailed description on jointing procedure shall be furnished during detailed engineering.

ix) The details of the performance of end terminations / straight through joints as offered with the period in service in reputed Indian Utility should be furnished for 145 KV & 245 KV and reputed International/ Indian utility for 420 KV Cable accessories for evaluation of the techno-commercial offer.

x) The accessories shall be Type Tested as per relevant IEC 60840 & Type test report shall have to be furnished for technical evaluation.

3.20.29 WORKING PROCEDURE FOR TERMINATION

(i) At cable terminating end sufficient length of spare cable shall be left in the ground and at cable tray also at GIS, for future needs.

(ii) The rise of the cable immediately from the ground shall be enclosed in PVC/ PE pipe of suitable diameter to protect against direct exposure to the sun.

(iii) The cable shall be properly fastened using non-metallic clamps.

(iv) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.

(v) The sealing end shall be mounted on pedestal insulators to isolate them from their supporting steel work.

(vi) Protection from contact with the exposed metal work at the termination shall be provided by resin bonded glass fiber shroud.

(vii) Providing earth stations with all required materials, like leads, connectors etc. Earth pits shall conform to IS-3043:1987 (Code of practice for earthing).

3.20.30 WORKING PROCEDURE FOR JOINTING

(i) The cable jointing personnel and his crew shall have good experience and with HT license in the type of jointing and terminations that are used. The jointing works shall commence as soon as two or three lengths of cable have been laid. All care should be taken to protect the factory-plumbed caps/ seals on the cable ends and the cable end shall be sealed whenever the end is exposed for tests.

(ii) Jointing of cables in carriage ways, driveways under costly paving, under concrete or asphalt surfaces and in

proximity to telephone cables and was mains should be avoided wherever possible.

(iii) Sufficient overlap of cables shall be allowed for making the joints.

(iv) The joint bay should be sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed. **3 ph link box for cross bonding to be placed inside the bay with provision for easy access for maintenance purpose.**

(v) The joints of different phases shall be staggered in the jointing bay.

(vi) Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.

(vii) The materials used in the joints like ferrules, screen/ sheath continuity bonds, lugs etc. shall be of good quality and conform to standards.

(viii) The jointing tools shall be appropriate and as per the requirement of jointing HVXLPE cables.

(ix) SUMPHOLES

When jointing cables in water logged ground or under unforeseen rainy conditions, a sumphole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or drained out by buckets, without causing interference to the jointing operation.

(x) TENTS/COVERS

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open irrespective of the weather conditions. The joint shall be made in dust free, moisture free and clean atmosphere.

(xi) PRECAUTIONS BEFORE MAKING A JOINT

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/ inclement weather conditions which might become uncontrollable.

If the cable end seals of cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

(xii) MEASUREMENT OF INSULATION RESISTANCE

Before joining, the insulation resistance of both sections of cables shall be checked.

(xiii) The identification of each phase shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

3.20.31 BONDING OF SCREEN/ SHEATH

The screens at both ends, shall be brought out and bonded to the earth station through disconnecting type link boxes or through SVL wherever applicable. On the basis of the length of the cable and current carrying capacity, the bonding maybe required **as per IEEE 575** as follows:

1. Single End Bonding
2. Double End Bonding
3. Cross Bonding
4. Midpoint bonding

All accessories and consumables used in the termination should be of good quality and compatible with the cable. At the time of single end bonding parallel copper earth continuity conductor along the length of the cable shall have to be provided between the two ends of the cable. Bonding cable **of 1.1KV copper** XLPE insulated shall be provided for bonding of metallic sheath/ Screen.

The screens at both ends, shall be brought out and bonded to the earth station through disconnecting type link boxes or through SVL wherever applicable. On the basis of the length of the cable and rise of sheath Voltage the bonding maybe required as follows:

1. Single End Bonding
2. Double End Bonding
3. Cross Bonding
4. Mid point bonding

All accessories and consumables used in the termination should be of good quality and compatible with the cable. At the time of single end bonding parallel copper conductor along the length of the cable shall have to be provided between the two ends of the cable. Bonding cable of 6.6KV copper shall be provided for bonding of metallic sheath/ Screen.

3.20.32 CONNECTION OF RADIAL WATER BARRIER AND CABLE SCREEN

If the metallic radial water barrier is insulated from the metallic wire screen a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

3.20.33 STATUATORY APPROVAL OF WORKS

Contractor shall make an application on behalf of the owner for submission to the Electrical Inspectorate along with copies of required certificates complete in all respects and submit to the engineer-in-charge for onward transmission well ahead of time so that the actual commissioning of system/ equipment is not delayed for want of inspection by the Inspector. Contractor shall arrange the actual inspection of work by the Electrical Inspector. Necessary coordination and liaison work in this respect shall be the responsibility of the contractor.

The Inspection and acceptance of work as above shall not absolve the Contractor from any of his responsibilities under this contract.

Any other statutory approval of works required for the electrical installation (such as Factory Inspector, CCOE, etc.) is also included in contractor's scope.

Supply & execution of job is subjected to regulations time to time framed by the AERC; approval Govt. Of Assam, and NOC from Assam Pollution Control Board. Contractor shall complete the entire job in compliance with the same.

3.20.34 INSPECTION, TESTING AND COMMISSIONING

3.20.34.1 Inspection of Supplied materials and Site works time to time during execution: Inspection of AEGCL and clearance from AEGCL will be in Contractor responsibility. Expenditure related to this inspection will be in contractor account. Site inspection, testing and commissioning of electrical installation shall be carried out as per enclosed Specification and Inspection and Test Plans included or referred in this BID. All the equipment installed by the contractor shall be tested and commissioned, as required and no separate payments shall be made unless otherwise specified in the Schedule of Rates. Contractor shall carefully inspect all equipment and submit the manufacturer's Certificate before installation. Any damage or defect noticed shall be brought to the notice of the engineer-in-charge at that time and same shall be rectified or replaced by CONTRACTOR on his OWN RISK AND COST within TIME FRAME. Complete testing of power transmission system would be carried out under the supervision of the Employer.

3.20.34.2 Any work not conforming to the execution drawings, specifications or codes shall be rejected forthwith and the contractor shall carry out the rectification at his own cost.

3.20.34.3 The contractor shall carry out all the tests as enumerated in the tender and technical specifications and technical documents which may be furnished to him during performance of the work.

3.20.34.4 Before the electrical system is made live, the electrical contractor shall carry out suitable tests to establish to the satisfaction of the Employer that the installation of equipment, cabling/ wiring and connections have been correctly done and are in good working condition and that the system/ equipment will operate as intended.

3.20.34.5 All tests shall be conducted in the presence of Employer/ Engineer-in-Charge or his authorized representative unless he waives this requirement in writing. Contractor shall arrange testing equipment, as required to carry out the tests. Test results shall be recorded on approved Performa and certified records of the tests shall be submitted to the Employer/ Engineer-in-Charge.

3.20.34.6 Prior intimation to be given to the Employer before finalizing of date of scheduled inspection at least 15 days in advance.

3.20.34.7 Clearance in favour of contractor for dispatch of equipment/material from respective works of manufacturer will be covered by the Employer after physical inspection and witnessing satisfactory routine and acceptance tests. Contractor will have to arrange physical inspection and witnessing of Routine and Acceptance Test of materials/equipments at respective manufacturer's works by two engineer of the Employer and cost of such inspection shall have to be borne by contractor. Clearance for dispatch of equipments & materials from respective works of manufacturers will be conveyed by the Employer after verification and acceptance thereafter.

3.20.34.8 After the completion of all tests and rectification of all defects pointed out during final inspection, plant start-up trials shall commence. During the start-up trials, contractor shall provide skilled/ unskilled personnel and supervision round the clock at his own cost. The engineer-in-charge/Employer will decide the number and the category of workmen and their duration. Any defects noticed during the start-up trials relating to the equipment supplied and work carried out by the contractor, shall be rectified by the contractor at his own cost.

3.20.34.9 The Employer shall have the right to get the defects rectified at the risk and cost of the contractor if he fails to attend to the defects immediately as desired.

3.20.34.10 Contractor shall also inform the Employer/ Engineer-in-charge, well in advance in case services of any OEM (Equipment manufacturer) are required and same shall be arranged by Contractor at the time of commissioning on his own cost.

3.20.34.11 Contractor shall furnish site acceptance test (SAT) procedures from the equipment supplier and get it approved from the Employer/ Engineer-in-charge before carrying out the same at site.

3.20.34.12 Contractor shall prepare detailed testing, pre-commissioning and commissioning procedures for the entire installation. These shall include Performa for defining activities and recording of test results.

3.20.34.13 It is the responsibility of the contractor to coordinate and provide all necessary assistance to other contractors / agencies/ vendors involved in the complex for proper and timely execution of the works. Further contractor shall do all the liaisoning, documentation or other related formalities with respective authorities/agencies for successfully charging/commissioning of system.

3.20.34.14 The following equipment/ items as included in Contractor's scope of supply shall be tested and inspected by AEGCL or his authorized representative before dispatch at the manufacturer's works. Test certificates duly signed by AEGCL or his authorized representative shall be submitted by the contractor as part of the final document:

a) EHV cable & optical fiber cables and Linear Heat sensing cable.

b) Jointing & termination kits for above items.

3.20.35 ENGINEERING DATA AND DRAWINGS

The Bidder shall necessarily submit all the drawings/ documents unless anything is waived. The Bidder shall submit 4(four) sets of drawings/ design documents/ data/ test reports as may be required for the approval of the Employer.

All drawings submitted by the Bidder including those submitted at the time of bid shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal and the external connections, fixing arrangement required and any other information specifically requested in the specifications.

All engineering data submitted by the Bidder after final process including review and approvalbytheEmployershallformpartoftheContractDocumentandtheentireworks performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Employer in Writing.

3.20.36 INSTRUCTION MANUAL

(i) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.

(ii) If after the commissioning and initial operation, the instruction manuals require any modifications/ additions/ changes, the same shall be incorporated by the bidder in the final submission.

(iii) The Bidder shall furnish to the Employer catalogues of spare parts.

3.20.37 QUALITY ASSURANCE PROGRAMME

a. To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Bidder's Works or at his sub-bidder's premises or at the Employer's site or at any other place of work are in accordance with the specifications, the Bidder shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be outlined by the Bidder and shall befinally accepted by the Employer after discussions before the award of Contract.

b. Quality Assurance Documents

The Bidder shall be required to submit the following Quality Assurance Documents within three weeks before laying/ erection of the equipment.

(i) All Non-Destructive Examination procedures, stress relief and weld repair procedure actually used during fabrication and reports including radiography interpretation reports.

(ii) Welder and welding operator qualification certificates.

(iii) Welder's identification list, listing welder's and welding operator's qualification procedure and welding identification symbols.

(iv) Raw material test reports on components as specified by the specification and/or agreed to in the quality plan.

(v) Stress relief time temperature charts/ oil impregnation time temperature charts.

(vi) Factory test results for testing required as per applicable codes/ mutually agreed quality plan/ standards

referred in the technical specification.

(vii) The quality plan with verification of various customer inspection points (CIP) as mutually agreed and methods used to verify the inspection and testing points in the quality plan were performed satisfactorily.

3.20.38 EQUIPMENTS & STRUCTURES FOR CABLE TERMINATION

1. The terminating structure being provided should be designed as per the requirement of the cable end sealing, porcelain bushing etc. The mounting structure shall be fixed on the cement concrete foundation, the design and drawings of which shall be submitted to Employer for review and acceptance during the course of detailed engineering.

   After fixing the end termination, the cable shall be fixed to the support, with non- magnetic material clamps to the required height securely. The mounting structure includes the supports for cable end boxes, link boxes and any other structure required for the intent of the contract. All steel sections used shall be free from all imperfections, millscales, slag intrusions, laminations, fillings, rust etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Employer.
2. Suitable fencing should be provided at the cable terminating yard at cable conductor junction point. The fencing will consist of galvanized steel XPM structure over a brick wall of 2(two) feet meeting electrical requirement (IE). A suitable entry point (gate) has to be provided.
3. Outdoor type lightning arresters for each cable of both the circuits are to be provided at cable-conductor junction point. The technical specification of lightning arresters is given separately in this volume.
4. It is recognized that the Bidder may have standardized on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to the Employer. Unless brought out clearly, the Bidder shall be deemed to conform to this specification scrupulously. All deviations from the specification shall be clearly brought out in the respective schedule of deviations. Any discrepancy between the specification andthe catalogues or the bid, if not clearly brought out in the specific requisite schedule will not be considered as valid deviation.

5. Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification but which are necessary for commissioning and satisfactory operation of the work unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/ parts of similar standard equipment provided shall be inter-changeable with one another.

6. STEEL STRUCTURES (GANTRY, EQUIPMENTS ETC.):

A) The contractor shall assume full responsibility for supply, fabrication and detailing, if required of the steel structures and for their satisfactory performance. All detail drawings for the structures shall be supplied to the successful bidder by the Employer/Engineer. However, the contractor shall have to submit the construction drawings to the Engineer/Employer solely prepared on the basis of these supplied drawings. Equipment Structure drawings, supplied by the employer, shall have to be modified to suit to the approved GA drawings of the equipment and electrical layout drg. And to be submitted to Engineer for approval. Employer/ Engineer shall have the right to instruct the contractor to make any changes in details necessary to make the construction conform to the requirement of the Contract Document.

B) The contractor shall supply all materials, deliver the same to site, and provide all labour, erection plant and equipment, fixtures, fitting and all temporary and permanent works necessary for satisfactory completion of the job in all respects.

C) No omissions or ambiguities on the drawings or in specifications will relieve the contractor from furnishing best quality of materials and workmanship. Should any inaccuracies be found, the contractor shall promptly notify the Employer/Engineer without carrying out the job and no further work shall be done before these discrepancies are corrected. Continuation of further work shall be done only after such discrepancies are rectified at contractor's risk and responsibility.

D) MATERIALS: The materials shall conform to the following requirements:

All Structural Steel Materials to be used in construction within the purview of the specification shall comply with :IS:2062 –Structural Steel (Grade-A) (fusion welding quality) and manufactured by Prime Rollers e.g. SAIL/ TISCO/ IISCO/ RINL. In case of MS sections not manufactured by prime rollers or such sections are not available with prime rollers the same is to be procured from approved conversion agents of prime manufacturer(s).In such case, prior approval of the Engineeris to be obtained by the contractor.

Successful bidder on receipt of structural drawing from department shall submit within 15 days, a detailed raw material procurement plan indicating MS sectionwise producers name to the Engineer for approval. On according approval in this aspect, work for fabrication protos shall be taken up in hands.

Entire fabrication job of MS structural shall not be entrusted to more than two sub- vendors. Further, a list of bonafide fabricators, not exceeding 6 (six) shall be furnished to the Engineer for according approval within 15(fifteen) days from the date of handing over of drawings.
All electrodes to be used under the contract shall comply with any of the following Indian Standard Specifications as may be applicable.

i) IS:814: Covered electrodes for metal arc welding of Structural Steel.

ii) IS:815: Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.

iii) IS:144: Covered electrodes for the metal arc welding of high tensile structural steel.

All bolts and nuts shall be of grade 5.6HRH and shall conform to the requirements of IS:6639 and IS:1367 and galvanizing quality shall be as per IS:1367. All bolts and nuts shall be of minimum diameter of 16mm unless otherwise stated. All mildsteel for bolts and nuts when tested in accordance with the following Indian Standard specification shall have a tensile strength of not less than 44Kg/Sq.mm. and a minimum elongation of 23 percent on a gauge length of 5.6A, where `A' is the cross sectional area of the test specimen-

i) IS:1367: Technical supply conditions for threaded fasteners.
ii) IS:1608: Method for tensile testing of steel products other than sheet, strip, wire and tube.

Washers shall be made of steel conforming to IS:226, IS:961 as may be applicable under the provisions of the contract and shall be electrogalvanized.
7 FASTNERS & CONNECTIONS:

a) BOLTS: All connections shall be bolted with 16mm bolts.

b) SPLICES: Splicing shall be avoided unless the length of a member exceeds 6.0 m or so. The member of splices shall be limited to a practical minimum. No credit shall be allowed for bearing on a butting areas. Lap joints in leg members shall be preferred to butt joints.

c) STEP BOLTS: Step bolts shall be of 16mm diameter and shall have round or hexagonal head. Each step bolt shall be provided with two hexagonal nuts. The minimum bolt length and length of unthreaded portion shall be 180 and 125mm respectively. Step bolts shall not be used as connection bolts. The step bolts shall be spaced alternately on the inner gaugelineoneachfaceoftheangleabout40cmcenters.Theyshallbefurnished for one leg of each steel structure column from its base elevation.

d) U – BOLTS: U-Bolts shall be suitable furnished or steel structures to suspend or terminate insulator strings or

ground wire assemblies. Size of U-bolt shall withstand all loads acting on it.

e) BILL OF MATERIAL: Bill of material shall give the size, length and weight of each member and the total weights of steel structures. It shall also include the number of bolts, nuts and washers per structure.

3.20.39 MATERIAL/ WORKMANSHIP

Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential 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, the Employer shall decide upon the question of similarity. When required by the specification or when required by the Employer the Bidder shall submit, for approval, all the information concerning the 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 Bidder.

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 expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the Employer.

Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.

All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless otherwise specified, shall include unpacking, cleaning and lifting into position, grouting, leveling, aligning, coupling of or bolting down to previously installed equipment bases/ foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer's tolerances, instructions and the Specification.

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.

3.20.40 PACKAGING & PROTECTION

a. All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. On request of the Employer, the Bidder shall also submit packing details/ associated drawing for any equipment/ material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes in India should be taken into account. The Bidder shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharf age and other such charges claimed by the transporters, railway etc. shall be to the account of the Bidder. Employer takes no responsibility of the availability of the wagons.

b. All coated surfaces shall be protected against abrasion, impact, discoloration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and piping and conduit equipment connections shall be properly sealed with suitable devices to protect them from damaged. The parts which are likely to get rusted, due to exposure to weather should also be properly treated and protected in a suitable manner.

3.20.41 FINISING OF METAL SURFACES

a. All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed shall be hot-dip galvanized after fabrication. High tensile steel nuts and bolts and spring washers shall be electro galvanized to service condition. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized accordingtoIS:2629.

b. HOT DIP GALVANISHING

The minimum weight of the zinc coating shall be **900gm/sq.m** and minimum thickness of coating shall be **130 microns for outdoor and minimum thickness of coating shall be 85 microns for indoor for all items thicker than 6mm.** For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface, which shall be embedded in concrete the zinc coating shall be 610gm/sqm minimum.

c. The galvanized 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 like 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 galvanizing no drilling or welding shall be performed on the galvanized parts of the equipment excepting that nuts may be threaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.

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

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

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

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

d. PAINTING

i) All sheet steel work shall be degreased, pickled, phosphate in accordance with the IS-6005 “Code of practice for phosphating iron and sheet”. All surfaces which will not be easily accessible after shop assembly shall be forehand be treated and protected for the life of the equipment.

ii) The surfaces, which are to be finished painted after installation or require corrosion protection until installation shall be shop painted with at least two coats of primer. Oil, grease, dirt and swaf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

iii) After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved.

iv) After application of the primer, two coats of finishing synthetic enamel paint shall be applied each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting.

v) The exterior color of the paint shall be as per shade no: 697 of IS-5 and inside shall be glossy white for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective sections of the equipments. Each coat of primer and finishing paint shall be slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipments.

vi) In case the Bidder proposes of follow his own standard surface finish and protection procedures or any other established painting procedures like electrostatic painting etc. the procedure shall be submitted along with the Bids of Employer's review and approval.

3.20.42 HANDLING, STORING AND INSTALLATION

a. In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Employer or his representative, the Bidder shall unload, store, erect, install, wire, test and place in to commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workman like manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energization at rated voltage.

b. Bidder may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Bidder shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.

c. In case of any doubt/ misunderstanding as to the correct interpretation of manufacturer's drawings or instruction, necessary clarifications shall be obtained from the Employer. Bidder shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings / instructions correctly. Where material/ equipment is unloaded by Employer before the Bidder arrives at site or even when he is at site. Employer by right can hand over the same to Bidder and there upon it will be the responsibility of Bidder to store the material in an orderly and proper manner.

d. The Bidder shall be responsible for making suitable indoor storage facilities to store all equipment, which require indoor storage.

e. The words 'erection' and 'installation' used in the specification are synonymous.

f. Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.

g. The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 4.7.1 the Bidder shall immediately proceed to correct the discrepancy at his risks.

3.20.43 QUALITY CONTROL:

a. The contractor shall establish and maintain quality control procedures for different items of work and materials to ensure that all work is performed in accordance with the specifications and best modern practice.

b. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer. As far as possible all inspection by the Engineer or Engineer's representative shall be made at the Contractor's fabrication shop whether located at site or elsewhere. The contractor shall cooperate with the Engineer in permitting access for inspection to all places where work is being done and in providing free of cost of all necessary help in respect of tools and plants, instrument, labour and material required to carry out the inspection. Materials or workmanship not in reasonable conformance with the provisions of this specification may be rejected at any time during the progress of the work.

c. The quality control procedure shall cover but not be limited to the following items of work :

d. Steel: Quality, manufacturer's test certificates, test reports including procurement in-voice of representative samples of materials from unidentified stocks if permitted to be used.

e. Bolts, nuts & Washers: Manufacturer's certificate, dimension check, material testing

f. Electrodes: Manufacturer's certificate, thickness and quality of flux coating.

g. Welds: Inspection, X-ray, ultrasonic test, magnetic particle tests as required

h. Paints: Manufacturer's certificate, physical inspection reports.

i. Galvanizing: Tests in accordance with IS:2633 – Method of testing uniformity of coating on zinc coated articles and IS:2629 Recommended practice for hot - dip galvanizing of iron and steel. Raw zinc & samples collected from bath shall be tested at third party laboratory as per direction of the Engineer.

j. The contractor shall submit a detailed material inspection plan on the basis of various IS codes & standard practices in respect of structural fabrication, galvanization, bolts, nuts, anchor bolts etc. much prior to commencement of the job.

3. 20.44 FABRICATION WORKMANSHIP:

3.20.44.1 All workmanship shall be equal to the best practice in modern structural shop and shall conform to the provisions of IS:800/ IS:802.

3.20.44.2 Rolled materials before being laid off or worked, must be clean free from sharp kinks, bends, or twists and straight within the tolerances allowed by IS:1852. If straightening is necessary it may be done by mechanical means or by the application of a limited amount of localised heat not exceeding 600^{o}C.

3.20.44.3 Cutting shall be effected by shearing, cropping or sawing. Use of mechanically controlled Gas Cutting Torch may be permitted for mild steel provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. To determine the effective size of members cut by gas, 3mm shall be deducted from each cut edge.

3.20.44.4 The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2mm at each end. The erection clearance at ends of beams without cleats shall not be more than 3mm at each end, but where for practical reasons greater clearance is necessary, suitably designed clearance shall be provided.

3.20.44.5 All members shall consist of rolled steel sections.

3.20.44.6 Holes for bolts shall not be more than 1.5mm larger than the diameter of the bolt passing through them unless otherwise stated.

3.20.44.7 All members shall be cut to jig and all hole shall be punched and drilled to jig. All parts shall be carefully cut and holes accurately located after the members are assembled and tightly clamped or bolted together.

3.20.44.8 Drifting or rimming of holes shall not be allowed. Holes for bolts shall not be formed by gas cutting process.

3.20.44.9 Punching of holes will not be permitted for M.S. members upto 8mm thick and in no case shall a hole be punched where the thickness of the material exceed the diameter of the punched hole.

3.20.44.10 Minimum bolt spacing and distances from edges of members shall in accordance withthe provisions in the relevant Indian Standard Specification.

3.20.44.11 Built members shall, when finished, be true and free from all kinds of twists and open joints and the material shall not be defective or strained in any way.

3.20.44.12 All bolts shall be galvanized including the threaded portion except the foundation bolts for which galvanizing work shall be done for a length of 100mm (min) to 175mm (max) measured from the tip of the treaded portion. The threads of all bolts shall be cleared of smelter by spinning or brushing. A die shall not be used for cleaning the threads unless specially approved by the Engineer. All nuts shall be galvanized with the exception of the threads which shall be oiled. In case of foundation bolts the same shall be galvanized excepting the length of embedment.

3.20.44.13 When in position all bolts shall project through the corresponding nuts but not exceeding 10 mm. The nuts of all bolts attaching insulator sets and earth conductor clamps to the structure shall be carefully positioned as directed by the Engineer.

3.20.44.14 Bolts and nuts shall be placed in such a way so that they are accessible by means of an ordinary spanner.

3.20.44.15 Foundation bolts shall be fitted with washer plates or anchor angles and flats, nuts etc. and shall be manufactured from mild or special steel.

3.20.44.16 Washers shall be tapered or otherwise suitably shaped, where necessary to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least by 3mm. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut. In addition to the normal washer, one spring washer or lock nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified in the drawings

3.20.44.17 The thickness of spring washer shall be 3.5 mm for bolt diameter 16 mm and 4 mm for bolt diameter 20 mm.

3.20.45 CLEANING & GALVANIZING:

3.20.45.1 CLEANING:

After fabrication has been completed and accepted, all materials shall be cleared off rust, loose scale, dirt, oil grease and other foreign substances.

3.20.45.2 GALVANIZING:

All materials shall be hot-dip galvanized after fabrication and cleaning. Re tapping of nuts after galvanizing is not permitted.

Galvanizing for structural mild steel products shall meet the requirements of IS:4759. All holes in materials shall be free of excess spelter after galvanizing.
Galvanizing for fasteners shall meet the requirements of IS:1367. The spring washers shall be electrogalvanized as per IS:1573.
Finished materials shall be dipped in to the solution of dichromate after galvanizing for white rust protection during transportation.
All galvanizing shall be uniform and of standard quality. Quantity of zinc shall meet the requirement of IS:209.
Mass of Zinc Coating:
The mass of zinc coating for different class of materials, as given in Table below, shall be followed:

MASS OF ZINC COATING

Sl. No.	**Product**	**Electro meter reading (micron)**	**Minimum value of average mass of coating**
i)	Casting - gray iron, malleable iron		610 (gm/m2)
ii)	Fabricated steel articles :		
a)	5 mm thick and over	86	610
b)	Under 5 mm, but not less than 2 mm	65	460
c)	Under 2 mm, but not less than 1.2mm	48	340
iii)	Threaded work other than tubes and tube fittings :		
a)	10 mm dia and over	43	300
b)	Under 10 mm dia	39	270
iv)	All Outdoor structures	130	900

Technical Specification of Distributed Temperature Monitoring System (DTS)

The bidder shall include and provide separate "Distributed Temperature Monitoring System (DTS)" for entire route for EHV Cables complete in all respects along with terminal coupling equipment, workstation and required hardware and software for real time monitoring of conductor temperature profile (with ambient temperature compensation) and to provide dynamic power load predictions of the cable based on relevant IEC standards. The offered system should be able to provide maximum possible transmission capacity of the cable for each circuit. The distributed temperature monitoring system shall be optical fiber based, must be of proven technology and should be in operation for similar use along with EHV cables as per latest practices. The DTS shall be inherently resistant to taking a given reading and giving a false alarm due to the requirement for multiple physical effects (Viz. temperature/hot spot, strain, arc flash, optical Loss, Fiber Break, Conductor break, etc.) to simultaneously occur at the same location to signify an event and trigger an alarm with Geo-tags. The DTS system can be calibrated to run very quick (a few seconds), lower accuracy (±1°C) scans of the fibre for temperature changes or to take a slower (half a minute) more detailed scan for maximum accuracy (±0.25°C) of temperature to sense even the smallest changes. The DTS shall be passive, no electricity is required in the field. Also, no maintenance or calibration shall be required after commissioning. The self-diagnostics of DTS shall monitor the unit's condition and maintain optimum performance. The DTS shall not be affected by electromagnetic fields (EMF), lightning or weather events. The DTS unit can be attached as a loop to both channels on independent fibres and in the event of a cut will report the damage, but continue to monitor the fiber on both sides up to the cut. The "terminal coupling equipment" and "workstation" shall preferably be microprocessor based with HMI, for displaying temperature along the length of the cable system. System shall provide potential free output contact for signaling to SCADA. The bidder shall provide brochures and catalogues for offered distributed temperature monitoring system along with the bid. Optical fiber cables along with all joining accessories etc. required for DTS shall also be included in the scope of bidder. Optical fiber cable associated with DTS shall be laid in the same EHV cable trench/raceway.

General Technical Specifications of DTS

(All blank parameters shall be filled-up by Vendor/EPC)

Sl. No.	Parameter	Description
1.	Sensing Element	Fibre Optic Sensing Cable
2.	Number of channels (Dual Channel)	
3.	Interrogator operating Temperature	0-50°C
4.	operating Humidity (max)	As per GTR
5.	Dimensions (Rack mounted)	
6.	Weight (Kg)	
7.	Power Supply (V)	
8.	Power consumption (W)	
9.	Sensing Range (DTS) (km) Loop Per channel	
10.	Spatial Resolution (250 or 500mm)	
11.	Frequency Response	1Hz-120kHz (Range Dependant)
12.	Temperature sensing range (cable)	-5°C to 700°C
13.	Accuracy	
14.	Resolution	
15.	Scan Time	
16.	Light Source	Laser (Infra-red) Class 1M
17.	Laser Wave Length	As per IEC
18.	Laser Stability	As per IEC
19.	Acquisition rate	
20.	Processor Acquisition Rate	64Bit (Ultra high speed)
21.	Operating System	
22.	Output	Modbus, Ethernet, TCP/IP (Standard), Relay, USB, SCADA, IEC 61850 or equ
23.	Remote Interfacing	Ethernet and 4G/5G enabled
24.	Processer architecture	Field programmable gate array (FPGA)
25.	Data Storage (Removable)	2x 2TB HDD (removable) [Minimum]
26.	Data Storage (Internal)	128GB Solid State Drive [Minimum]
27.	Dynamic Range	
28.	Standard	IEC 61757-2-2: 2016 and other relevant IEC
29.	Any other parameters to be filled by Manufacturer	
30.	Firmware and software details (Latest Version)	
31.	Warranty Period	
32.	License validity period (if any)	
33.	Measurement reach (km)	

Table 2: SPECIFICATION FOR DESIGN AND FABRICATION OF SUB STATION STEEL STRUCTURES

STRAIGHTENING AFTER GALVANIZING:

All plates and shapes which have been warped by the galvanizing process shall be straightened by being rerolled or pressed. The materials shall not be hammered or otherwise straightened in a manner that will injure the protective coating. If, in the opinion of Employer/ Engineer the material has been forcibly bent or warped in the process of galvanizing of fabrication, such defects shall be cause for rejection.

REPAIR OF GALVANIZING:

Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized, unless, in the opinion of Engineer, the damage is local and can be repaired by zinc spraying or by applying a coating of galvanizing repair compound. Where re-galvanizing is required, any member which become damaged after having been dipped twice shall be rejected.

SHOP ASSEMBLY:

One of each type of steel structures shall be assembled in the shop to such an extent as to ensure proper field erection in order to facilitate inspection by the Engineer.

SHOP TEST:

The following shop tests shall be performed with relevant provisions of I.S. Codes :

a) General Inspection
b) Material test.
c) Assembly test.
d) Galvanizing test.

The contractor shall furnish four certified copies of reports of all tests to the Engineer.

DESIGN OF FOUNDATIONS:

3.20.45 STEEL STRUCTURE FOUNDATIONS:

The foundations shall be designed such that the upper structure shall be securely supported. Any unequal displacement that may cause harmful effect to the upper structures shall not be allowed. The safety factors for strength and stability of the foundations shall be as per relevant code.

The overload factor shall be taken as 1.1 for designing foundations of all gantry and equipment. The loads, shear and moment values shall be multiplied with this overload factor, so as to obtain the design values

3.20.46 WEIGHT OF SUB-STATION STRUCTURES:

Self-weight of line tower, A-frame and equipment structures for different gantry and equipment structures shall be provided at the time of detail engineering.

3.20.47 Technical Specification for Underground Fibre Optic Cable

This section describes the functional requirements, major technical parameters and Type testing, Factory Acceptance Testing & Site Acceptance Testing requirements for underground fibre optic cables and HDPE pipes. Marking, packaging, transportation & installation requirements have also been described. The payment will be made for the executed route length only. However, specified service loops and lengths for wastage, installation/working for FO cable & HDPE ducts shall be considered as required by the bidder for which no additional payment will be made.

3.20.48 General

The underground fibre optic cable shall be armoured and shall be suitable for direct burial as well as for underground installation in pipes. The cable should be of low weight, small volume and high flexibility. The mechanical design and construction of each unit shall be inherently robust and rigid under all condition of operation, adjustment, replacement, storage and transport. The fibre optic cable shall be a UV resistant, rodent proof. The underground fibre optic cable (UGFO) shall be offered from a manufacturer who has been manufacturing UGFO for the last five (5) years and UGFO manufactured & supplied by such manufacturer shall have been in satisfactory operation.

3.20.49 Applicable Standards

The cable shall conform to the standards named below and the technical specifications described in the following sections.

i). ITU-T Recommendations G.652
ii). Electronic Industries Association, EIA/TIA 455-78A, 455-3A/33/41/25A / 81A / 82B, 455-62A, 455-164A/167A/174, 455-168A/169A/170/175A, 455-176, 455-59, EIA/TIA 598, EIA 455- 104.
iii) International Electro technical Commission standards, IEC60304, IEC60794-1-2, IEC60811-5-
iv) Bellcore GR-20
v) Indian Railways standard specification no IRS:TC55(Oct 96) (including all amendments)
vi) ASTM:A167-92,ASTM:751-92b,ASTM:A751-92,ASTM:A370-82,ASTM:D2581-91,ASTM:D2287-81, ASTM:D 638 for FRP, ASTM :D 217,556, 93-IP-34 for Jelly, ASTM:D 570,211 for PBTP, ASTM:D1505for Poly Carbonate, ASTM:D1633,150 for HDPE.

3.20.50 Fibre Type(s) and Counts

The Cable shall consist of 24 fibres Dual-Window Single mode (DWSM), G.652 optical fibres and shall meet the requirements stipulated in Table 1

DWSM Optical Fibre Characteristics (Table-1)

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 µm (± 0.6 µm)
Cladding Diameter:	125.0 µm +/- 1 µm
Mode Field concentricity error	≤0.6%
Cladding non-circulatory	≤ 1%
Cable Cut-off Wavelength λ_{cc}	≤ 1260 nm
1550 nm loss performance	As per G .652
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km
Chromatic Dispersion; Maximum: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339 nm 5.3 ps/(nm x km) 1271-1360 nm 1300 to 1324 nm 0.092 ps/(nm^{2}xkm) maximum
Polarization mode dispersion Coefficient	≤0.2 ps/km$^{\wedge 1/2}$
Temperature Dependence:	Induced attenuation ≤ 0.05 dB (-60^{0}C - + 85^{0}C)
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤0.05 dB @ 1550 nm (30±1 mm radius Mandrel) 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB

3.20.51 General Cable Construction

Consist of a central fibre optic unit protected by one or more layers of helically wound anti-hygroscopic tape or yarn. The central fibre optic unit shall be designed to house and protect the fibres from damage due to forces such as crushing, bending, twisting, tensile stress and moisture, wide temperature variations, hydrogen evolution etc. The fibre optic unit shall be of loose tube construction. The inner polyethylene jacket and outer sheath jackets shall be free from pinholes, joints, splits or any other defects. All fibre optic cable shall have a minimum service life span of 25 years. The cable construction and mechanical parameters for the Armoured OFC shall be as specified in the Table 2 below.

Table 2
Armoured Cable Construction and Mechanical Parameters

Parameter	Units	Description
No of fibres in the cable		24
Type of fibres in the cable		G.652
No. of loose tubes		Minimum 2
Cable design life		More than 25 years

3.20.52 Colour Coding & Fibre Identification

Individual optical fibres within a fibre unit, and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme. The colour coding system shall be discernible throughout the design life of the cable. Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing. Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres are included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibre shall be suitably bundled, tagged, and identified at the factory. The colouring scheme shall be submitted along with the cable DRS/drawing for Employer's approval.

3.20.53 Strength Members

The armoured optical fibre cable shall have solid non-metallic strength member(s)/ Solid metallic member(s) or the combination of both. The metallic strength member shall be of high grade steel wire, music spring quality as per ASTM-A228/A228M-93 and shall have suitable chemical coating for proper adhesion with sheath material. The central fibre optic unit should include a central strength member of non-metallic Fibre Reinforced Plastic (FRP) only. Peripheral strength members and aramid yarns are also acceptable. The central FRP strength member may be of slotted type with SZ lay (reverse oscillation lay) of fibre units or it may be

cylindrical type with helical or SZ lay of fibre units. The construction of the central strength member shall be such as to meet the mechanical strength requirements specified in this specification.

3.20.54 Filling Compound

The interstices of the central fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any longitudinal water migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per **IEC60794-1-2-F5**. The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, anti-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable. The filling compound shall remain stable for ambient temperature up to +70°C and shall not drip, flow or leak with age or at change of temperature. Reference method to measure drip point shall be as per **IEC 60811-5-1** and drip point shall not be less than 70°C.

3.20.55 The Sheath / Inner jacket

The Sheath shall be made of High Density Polyethylene-HDPE (Red /Black) and shall be smooth, concentric, and free from holes, splits, blisters and other surface flaws. The sheath shall be extruded directly over the central fibre optic unit and shall also be non-hygroscopic. The cable sheath design shall permit easy removal without damage to the optical fibres or fibre units. The sheath shall be made from good quality of weather resistant polyethylene compound HDPE and thickness shall be > 1.5mm including the strength member if used in the sheath.

3.20.56 Armouring of cable

Over the inner PE sheath armouring and outer sheath shall be provided to make the cable termite and rodent proof. The thickness of the stainless steel alloy armour shall be > 0.125mm. The steel armour shall be both side coated with a copolymer of thickness > 0.05mm so as to bond the armouring to the outer jacket and make a unitary construction. Stainless steel shall be armouring corrugated transversely for lateral strength and bending flexibility to be applied longitudinally with an overlap of 10% (minimum) over the inner PE sheath. The corrugation over the entire length of the tape used in the cable shall be uniform, electrically continuous (applicable to all metallic elements used in the cable) and bonded to the outer sheath. The force of adhesion of the armour to the outer sheath shall be minimum 14 Newton and shall be tested as per ASTM:4565 test method. Suitable glue adhesive should be provided in between overlap portion of cable armouring for bonding to avoid ingress of moisture (below the armour). The height of the corrugation shall be 0.6mm (min.) and the pitch shall be 2.5mm(max.). Height and pitch of corrugation shall be measured between crest and tough base line. The corrugated armouring of stainless steel shall offer excellent corrosive resistance and shall be AISI Alloy no. 304 and the chemical composition and mechanical properties of steel shall be as specified in table 1 & 2 of ASTM : A167-92b for AISI 304 respectively.

3.20.57 The Outer Jacket

A non-metallic moisture barrier sheath (Red or Black in colour) shall be applied over the armour, which shall consist of tough weather resistance made of HDPE. The thickness shall be uniform and shall not be less than 2.0mm (Red in colour) for the cable having inner and outer HDPE sheath. The outer jacket shall have smooth finish and shall be termite resistant. The raw material and additive used to make the outer sheath termite proof shall be clearly mentioned by the manufacturer of the cable.

In case of HDPE material black in colour is used, the material from finished product shall be subjected to the following tests mentioned in Table 3 below;

Table 3	
1.Density	0.94 to 0.965 gm/cc
2.Melt flow index	< 0.8 gm/10 minutes at 1900 C
3.Carbon black content	(2.5+0.5)%
4.Carbon black Dispersion	Uniform dispersion
5.ESCR	No crack till 48H in 10% Igepal solution 50^0C
6.Moisture Content	<0.3% for 24H, ASTM D570
7.Tensile strength and Elongation at break	>2 Kg.mm^2 and > 500% respectively

Rip Cord: Suitable rip cord(s) shall be provided to open the outer sheath of the cable. The rip cord(s) shall be properly waxed to prevent wicking action and shall not work as a water carrier.

3.20.58 Mechanical Parameters & Tests: The offered cable shall meet requirement of mechanical characteristic & tests specified in this specification.

3.20.59 Cable drums, Marking, Packaging and Transport

All optical fibre cable shall be supplied on strong wooden drums provided with lagging with adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. The cable drum shall be suitable to carry underground fibre optic cable of required length. However, the exact lengths for drums to be supplied for each link shall be determined by the Contractor during detailed engineering/survey. Drum schedule shall be approved by the Employer before manufacturing the FO cable. Both cable ends in the drum shall be sealed and shall be readily accessible. The drum shall be marked with arrows to indicate the direction of rotation. Both the ends of the cable shall be provided with pulling

eye. The pulling eye and its coupling system should withstand the same tensile load as applicable to the cable. The following marking shall be done on each side of the cable drums.

i) Drum number
ii) Consignee's name and address
ii) Contractor's name and address
iv) Type of cable
v) Number of fibres
vi) Type of fibres
vii) Year of manufacturing, month & batch no
viii) Name of manufacturer
ix) Total cable length
x) Inner end marking and Outer end marking

Packing list supplied with each drum shall have all the information provided on marking on the respective cable drum and following additional information: OTDR length measurement of each fibre and Ratio of fibre and cable length.

3.20.60 Optical fibre cable marking

A suitable marking shall be applied in order to identify this cable from other cables. Marking on the cable shall be indelible, of durable quality, shall last long and shall be applied at regular interval of one-meter length. Marking shall be imprinted and must clearly contrast with the surface and colours used must withstand the environmental influences experienced in the field. The accuracy of the sequential marking must be within + 0.5% of the actual measured length. The sequential length marking must not rub off during normal installation. In case laser printing is used the marking shall not exceed 0.15 mm depth. The optical fibre cable shall have the following markings in every meter.

i) Type of Cable
ii) Running meter length
iii) Number of fibres
iv) Type of fibre
v) Laser symbol & caution notice
vi) Year of manufacture and batch no.
vii) Manufacturer's name
viii) Owner's Name

3.20.61 Operating Instructions

Complete technical literature in English with detailed cable construction diagram of various sub-component with dimensions and test data of the cable shall be provided. All aspects of installation shall also be covered in the handbook.

3.20.62 Test and Inspection:

`Type Testing

The Bidder shall offer only the type tested cable and submit along with their bid the earlier carried out type test reports for the offered fibre optic cable meeting the requirement. The Contractor shall submit the previously carried out type test report for the same design of cable for the tests listed in Table below. The fibre should have been type tested as per relevant International standards for the tests listed in Table below and the Bidder shall submit the test reports and certificates along with the bid. The Contractor shall submit the type test reports of fibres meeting the minimum requirement specified in Tables below.

Type Tests Fibre Optic Cable
TABLE-4

S. No	Test Name	Test Procedure
1	Water Ingres Test	(IEC 60794-1-F5/EIA 455-82B) Test duration:24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning: 72 hours, Test duration: 24 hours
3	Crush test	IEC 60794-1-E3/EIA 455-41)
4	Impact test	(IEC-60794-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A)-2 cycles

Type Tests Fibre Optic Cable
TABLE-5

5	Attenuation with Bending (Bend Performance)		IEC 60793-1-47 or EIA/TIA 455-62A
6	Mode Field dia.	As per TS	IEC 60793-1-45 0r EIA/TIA 455-164A/167A/174
7	Chromatic dispersion		IEC 60793-1-42 or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 or EIA/TIA 455-176
9	Point Discontinuities of attenuation		IEC 60793-1-40 or EIA/TIA 455-176
10	Core-Clad concentricity error		IEC 60793-1-20 or EIA/TIA 455-176
11	Fibre Tensile proof testing		IEC 60793-1-30 or EIA/TIA 455-31B

Factory Acceptance Testing

The tests listed in Table below shall be carried out as Factory Acceptance Test for Underground fibre optic cable meeting the requirements specified in this section.

S. No	Test Name	Acceptance Criteria	Test Procedure
1	Attenuation	As per TS	IEC 60793-1-40 or EIA/TIA 455-78A
2	Attenuation Variation with wavelength		IEC 60793-1-40 or EIA/TIA 455-78A
3	Attenuation at Water Peak		IEC 60793-1-40 or EIA/TIA 455-78A
4	Temp Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 or EIA/TIA 455-3A, 2 cycles

Factory Acceptance Tests on Underground Fibre Optic Cable

Sl No	Factory Acceptance Test
1	Attenuation Coefficient (1310, 1550): By EIA/TIA 455-78A or OTDR
2	Point discontinuities of attenuation: By EIA/TIA 455-78A or OTDR
3	Visual Material verification dimensional checks as per approved drawings

3.20.63 PLB HDPE PIPE and ACCESSORIES

The following paragraphs describe the functional requirements, major technical parameters and Type and Factory Acceptance Testing requirements for Permanently Lubricant High Density Polyethylene (PLB HDPE) Pipe. PLB HDPE pipe shall be suitable for underground fibre optic cable installation by blowing as well as conventional pulling. The PLB HDPE pipe shall be suitable for laying in trenches by directly burying, laying through G.I/RCC hume pipe and laying through trench less digging. The expected service life of HDPE pipe and accessories shall not be less than 50 years. The unit rates quoted in the price schedule shall be the composite price of PLB HDPE pipe along with all accessories.

3.20.64 Construction of PLB HDPE pipe

The PLB HDPE pipe shall have two concentric layers viz. outer layer and inner layer. The outer layer shall be made of HDPE material and the inner layer of solid permanent lubricant. These concentric layers shall be co-extruded and distinctively visible in cross section under normal lighting conditions and generally conform to IS-9938. The colour of the PLB HDPE pipe shall be finalized during detail engineering. In the finished PLB HDPE pipe, the co-extruded inner layer of solid permanent lubricant shall be continuous and integral part with HDPE outer layer and preferably be white in colour. The inner layer of solid permanent lubricant shall not come out during storage, usage and throughout the life of the pipe. The pipe shall be supplied in a continuous length of 1000 (one thousand) meter in coil form, suitable for transportation, installation and handling purposes. The finished pipe shall be of good workmanship such that the pipe is free from blisters, shrink holes, flaking, chips, scratches, roughness, break and other defects. The pipe shall be smooth, clean and in round shape, without eccentricity. The ends shall be cleanly cut and shall be square with axis of the pipe.

3.20.65 General

The HDPE pipe shall conform to the following standard and the technical specifications described in the following sections.

a) IS: 4984 / IS: 2530/IS:14151/(part1)/ IS:9938/IS:7328/IS12235(Part-9)/IS:5175

b) ASTM D 1693/ ASTM D 638/ ASTM D 648/ ASTM D 790 / ASTM D 1712/
ASTM D 2240/ ASTM D 4565 / ASTM F 2160/ ASTM G 154

c) TEC-spec no. GR/CDS-08/02/NOV-04(including all amendments)-HDPE pipe for
use as duct for optical fibre cable.

3.20.66 Installation of Underground Fibre Optic Cable System

The Underground Fibre Optic Cable shall be installed along the power cable to be supplied & installed under this Project. This part of the section describes the installation procedures, installation of PLB HDPE pipes, installation of RCC hume pipes and GI Pipes, marking, backfilling, installation of underground FO cable, construction of manholes, splicing, termination and site acceptance testing requirements of the underground fibre optic cabling system.

3.20.67 Underground Fibre Optic Cable Installation

The cable shall be installed inside the 40mm diameter PLB HDPE pipe installed under this package along the route(s). Generally the cable shall be installed by compressed air blowing technique. However, for spans upto 150 meter, the Contractor can use pulling method for installation of OFC in HDPE pipe. If any temporary manhole or hand hole is required for installation of OFC, the same will be done by the Contractor without any additional cost implication. Adopting pulling method for installation of OFC for spans more than 150 meter, shall be subjected to approval of the Employer and shall be substantiated by proper justification. Contractor shall take into consideration the following guidelines, for installation of OFC approval by the Employer.

a. The Optical Fibre Cable Drums shall be handled with utmost care. The drum shall not be subjected to shocks by dropping etc. They shall not be normally rolled along the ground for long distance and when rolled, shall in the direction indicated by the arrow. The battens shall be removed only at the time of actual laying.

b. A blowing machine in association with an appropriate compressor shall be used for blowing.

c. Temporary blowing chambers (if required) shall be constructed and then backfilled after blowing operation is completed.

d. Locations along the route, which provide easy access points for blowing machine and compressor, shall be determined.

e. Before starting the cable blowing, PLB HDPE pipe shall be checked for obstacles or damage. Checking shall be done by using a proper sized mandrel.

f. Always blow downhill wherever possible.

g. Multiple blowing machines may be used in tandem if so required.

h. Care must be taken not to violate the minimum bending radius applicable for the fibre optic cable. Tension in the cable during laying shall not exceed tension limit of the OFC. Installation by pulling may be permitted by the Employer only in specific cases where installation by blowing is not feasible on specific approval from the Employer. In case pulling is used, the pulling speed shall be determined considering the site condition. While installing the cable, excess length of about 10 meters shall be stored at each joint location for each side. Excess length of 10 m shall be kept at one ends of a road crossing culvert crossing and 20 meters at one end of bridges. However, exact excess lengths and manhole locations shall be finalised during detailed engineering depending upon the site requirement.

As Built Drawings/details

The Contractor shall submit the as built drawings for the whole route indicating the route, depth of digging and manhole locations for easy maintenance of the installed system.

List of Drawings/documents required to be submitted for Employer's Approval

The Contractor shall ensure that the required drawings and documents are submitted well in time to avoid any delay in approval and project execution. The following minimum drawings and documents are required to be submitted by the Contractor for approval of the Employer:

a. The methods/procedures and the equipment/machines to be used for different types of trenchless digging techniques

b. Bill of quantities for various items as per contract

c. SAT Reports

d. As built drawings

3.20.68 Site Acceptance Testing (SAT)

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment/material for SAT shall be called Pre-SAT activities. During installation the Contractor shall maintain proper record of measurements in approved format and shall be given to the Owner/Employer (along with As Built drawing of the routes) for cross checking during SAT.

SAT for Excavation, Backfilling, Installation of Pipes, Manholes.

The tests shall include but shall not be limited to the following:

a. Depth Check: One sample every 200 mtrs, Contractor shall prepare a sample pit at a location identified by the Employer. Depth of each item, warning tape, no. Of warning bricks (if applicable), pipes, cable etc. Shall be measured. Depth shall be as per technical specifications and shall correspond to recorded measurements.

b. Crossings: 10% of each type, visual inspection for checking conformance with drawings, thickness of Concrete, RCC Hume Pipe and GI pipe.

c. Manholes: As per technical specifications.

After inspection the Contractor shall backfill and carry out other restoration work at no additional cost to the Owner/Employer.

SAT for Underground Fibre Optic Cable

SAT for optical fibre cable shall be carried out link by link. Prior to installation, every fibre optic cable segment shall be tested for continuity and attenuation and measurements shall be recorded. Test requirements are as per table 2-7. Any discontinuity or attenuation beyond permissible limits in any of the fibres has to be recorded and brought to the notice of Employer. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Test requirements are indicated in table 2-9 and in no case losses attributed due to other factors viz. Extra splice, kinks, will be acceptable to the limit determine by the following formula:

Max attenuation @ 1550 nm: 0.21dB/km + 0.05dB x total no of splices + 0.5dB x connector

Max attenuation @ 1310nm: 0.35dB/km + 0.05dB x total no of Splices + 0.5dB x connector

Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable failure during installation. The Contractor shall have to either replace the concerned cable span at its own cost or provide additional splicing, joint box and manholes required to rectify the fault at its own cost. The fibre attenuation shall be tested again after replacement or rectification of fault. In case it is found that the splices are bad (loss is unacceptable as per approved test procedures), the Contractor shall have to do re-splicing and provide new Joint Box wherever required at no additional cost to the Owner/Employer. After re-splicing the end to end testing shall be repeated. The splice testing requirements are indicated in table below.

Table 6: Fibre Optic Cable Pre-Installation Testing

Item	Description
1	Physical Inspection of the cable assembly for damage
2	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm

Table 7 : Fibre Optic Cable Splice Testing

Item	Description
1	Per splice attenuation with OTDR (bi-directional average) at 1550 nm
2	Physical inspection of Joint Box for proper fibre routing techniques
3	Physical inspection of sealing techniques, weatherproofing, etc

Table 8: Fibre Optic Cable Commissioning Testing

Item	Description
1	Fibre continuity and link attenuation (bi-directional) for each fibre at 1310 &1550 nm by OTDR
2	Fibre continuity and link attenuation (bi-directional) for each fibre at 1310 &1550 nm by Power Meter & Laser Source
3	Average splice loss (bi-directional) for each splices and average splice loss for the link by OTDR at 1550 nm.

SAT for PLB HDPE pipe

For PLB HDPE pipes, duct integrity tests shall be carried out as described below. The **Duct cleaning (Sponge test)** test shall be carried out on all the ducts before blowing/pulling of the cable between two consecutive manholes on the PLB HDPE pipes.

Duct cleaning (Sponge test)

Compressed air should be blown through the PLB HDPE pipe in order to remove dirt and water, if any, with the help of suitable Air Compressor. A short blast of air about 2-3 Bar shall be blown through the PLB HDPE pipe for about 2 minutes. Sponge shall be blown through the duct to thoroughly clean the duct from inside.

Crush and deformity test

Place a shuttle of length <15cm and O.D. 80% of the inner diameter of the offered PLB HDPE pipe. Connect the compressor pipe with a suitable flexible wire grip at the other end to catch the shuttle and start blowing operation to the pipe and check if shuttle reaches at the other end. If shuttle gets stuck the Contractor shall adopt suitable arrangement at site to locate the deformity/damage in the HDPE pipe, repair the pipe and ensure end-to-end continuity of the duct in sound condition.

3.20.69 Documentation

Apart from survey reports as mentioned above, the Contractor will submit the following documents after completion of the job and acceptance by the Employer:

(a) As built drawing of the route indicating the distance from road centre, OFC drum length, location of other utilities, link Q, OFC loop length, name of the road, sections and positions of PLB HDPE pipes, couplers, warning bricks/stone, manholes, G.I. pipes, RCC pipes, joint box, conduits, bends, trays, optical fibre cable loop lengths in manholes etc.

(b) Depth of PLB HDPE pipe in various sections of the route executed through open trenching.

(c) Sections of trenching digging executed through various methods.

(d) Specific deviation w.r.t. the installation and supply items, if any, from the technical specification. If there is no deviation, either explicit or implicit, the Contractor will provide a certification to this effect.

(e) Without submission of the above documentations, the Site Acceptance Testing of various items as described above will be deemed to be incomplete.

3.20.70 Miscellaneous Jobs

In order to provide end-to-end connectivity, it may be required to execute some miscellaneous jobs as detailed below.

Routing of Cables inside building.

In order to route the OFC (Optical Fibre Cable) from the underground trench to the control room building it is necessary to install the cable on walls inside PLB HDPE pipe over the existing cable tray/raceways inside the building.

Installation of PLB HDPE pipe on wall

The PLB HDPE pipe may be required to be installed on the wall using steel or G.I clamps. The contractor will provide the required clamps and other consumables sufficient for such installation. The contractor will take care of aesthetics while installation. The OFC will be pulled through the PLB HDPE pipe with due care as described in relevant Para of this specification.

3.20.71 INSPECTION & TESTING

Type Testing

Bidder shall offer the type tested product meeting the requirement of technical specifications.

Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Visual inspection shall be carried out on 100% basis for all the equipment/items offered. Factory acceptance testing shall be carried out on Underground fibre optic cable, Joint box, PLB HDPE pipe etc.

3.20.72 System Maintenance

The one year period commencing immediately after the operational acceptance is called the Defect liability Period/warranty period. Operational Acceptance shall be given on successful completion of SAT. During this period, the Contractor shall replace or repair all defective parts. The one year period commencing immediately after the operational acceptance is called the Warrantee Period/Defect Liability Period. During the Warranty Period/Defect Liability Period, the Contractor shall guarantee that there shall be minimum outage of the supplied system. During this period, the Contractor shall replace or repair all defective parts and shall have prime responsibility for maintaining an operational system.

3.20.73 Documentation

The documentation provided shall include the following:

(a) Detailed list of the deliverables
(b) Description of the products
(c) Technical particulars
(d) Installation manuals
(e) Maintenance manuals
(f) Quality assurance manuals, Manufacturing Quality Plan (MQP) & Field Quality

3.20.74 SPECIFIC TECHNICAL PARTICULARS FOR 33 KV XLPE CABLE

Sl.No.	Particulars	Details
1	Description of Cable	ARMOURING: ARMOURED CORE MATERIAL: COPPER INSULATION: XLPE NOMINAL AREA: As per BoQ. NO.OF CORE: Single Core SHEATHING MATERIAL: EXTRUDED PVC, INNER & OUTER VOLTAGE GRADE: 33KV
2	Highest system voltage	36 KV
3	Voltage Grade	19/ 33KV
4	Earthing System	Effectively earthed
5	Frequency	50 Hz
6	Size of Cable	As per BoQ
	No. of Core	1C
7	Rated Power Frequency Withstand Voltage (1 min)	70 KV (rms)
8	Impulse withstand BIL (1.2/ 50/ micro Sec) Line to earth	±170 kVp
9	Rated short time withstand current	31.5 KA (rms) for 1 sec
10	Rated peak withstand current (1 sec)	78.75 KA
11	No of phase per Ckt	3
12	Maxm.Conductor temp	90 degree C at maxm. continuous current
13	Maxm. Permissible short circuit Temperature	250 degree C for one second
14	End Sealing	H.S. Caps
15	**CABLE DETAILS : CONDUCTORS**	
i	Conductor material	Plain un-tinned annealed copper
ii	Conductor Shape	Compacted circular.
iii	Conductor Screen	Extruded, Cross-linked, semi conducting compound of suitable thickness. Semi conducting separator tapes with 50% overlap to be applied between conductor and conductor screen.
iv	Resistivity of the semiconducting screen	Maximum 1000 ohm-meter
16	**INSULATION**	
i	Insulation material	XLPE
ii	Insulation thickness	8.8 mm (Nominal thickness)
iii	specified insulation resistance at 90^0C	$1x10^{12}$ ohm cm
iv	Insulation Screen: Type & Material	Freely strippable (with heat) type extruded non-metallic semi conducting compound followed by copper metallic tape with minimum 25 % overlapping.
16	Resistivity of the semiconducting compound	Max 500 Ohm-meter
17	Longitudinal water barrier Material	Layer of semiconducting tape with suitable water swellable absorbent with 50% overlap.
18	Overall sheath	Extruded black HDPE (TypeST7) with anti termite and anti rodent treatment.
19	Coating of outer sheath	A hard baked layer of graphite or semi conducting layer shall be applied over the outer sheath as outer electrode for testing the sheath.
	Armouring	Armoured
20	**TESTS**	
i	Type Test	All tests as per specifications IEC Standards.
ii	Routine Test	All tests as per specifications IEC Standards.

iii	Acceptance Test	All tests as per specifications IEC Standards.
iv	Whether test will be witnessed by purchaser or his representative	Yes. Acceptance test will be witnessed.
21	Bending Radius	The minimum bending radius of XLPE insulated cables as follows: Cable: Bending radius Single Core: 25xD D – diameter of overall conductor.

3.20.75 SPECIFIC TECHNICAL PARTICULARS FOR 66KV, 132 KV & 220KV XLPE CABLE

Sl.No.	ITEMS	PARTICULARS
1	Description of Cable	Stranded single core compacted copper core screening by a layer of semi conducting tape followed by a layer of semiconducting compound as conductor screen, XLPE insulation, insulation screening with semiconducting compound extruded directly over the insulation, (semiconducting conductor screen, XLPE insulation, semiconducting insulation screen-all in one triple extrusion process), longitudinal sealing by a layer of water swellable semiconducting non woven tape over insulation screen, followed by radial sealing (**metal sheath of Corrugated Aluminum**),and overall extruded black HDPE Sheathed (TypeST7).
2	Highest system voltage	72.5KV 145KV 245KV
3	Voltage Grade	36/66KV 76/132KV 127/220KV
4	Voltage variation	+10% and -12.5%
5	Frequency	50 Hz
6	Frequency variation	±3%
7	Power frequency withstand voltage	90KV rms for 30 minutes 190 KV rms for 30 minutes 318KV for 30 minutes
8	Lightning impulse withstand voltage	±325KVpeak 650KVpeak 1050peak
10	No of phase per Ckt	3
11	Earthing system	Effectively earthed
12	Size of Cable	As per BoQ
13	Max. in Conductor Temp.	90ºC at maximum continuous current.
14	Fault level	31.5KA for 1 second 40Ka for 1 second 50KA for 1 second (considering parallel path of lead sheath and screen copper for metallic screen)
15	Maximum permissible short ckt temperature.	250ºC for one second.
16	**CABLE DETAILS : CONDUCTORS**	
16.1	Conductor material	Plain un-tinned annealed copper.
16.2	Conductor Shape	Compacted circular.

16.3	Conductor Screen	Extruded, Cross-linked, semi conducting compound of suitable thickness. Semi conducting separator tapes with 50% overlap to be applied between conductor and conductor screen.
16.4	Resistivity of the semiconducting screen	Maximum 1000 ohm-meter
16.5	Insulation	
	a)material	XLPE
	b)specified insulation resistance at 90^0C	$1x10^{12}$ ohm cm
16.6	Insulation Screen: Type & Material	Extruded semi conducting compound.
16.7	Resistivity of the semiconducting compound	Max 500 Ohm-meter
16.8	Longitudinal water barrier Material	Layer of semiconducting tape with suitable water swellable absorbent with 50% overlap.
16.9	Radial moisture barrier Material	Seamless or seam welded Corrugated Aluminum sheath with anti-corrosive material.
16.10	Overall sheath	Extruded black HDPE (TypeST7) with anti termite and anti rodent treatment.
16.11	Coating of outer sheath	A hard baked layer of graphite or semi conducting layer shall be applied over the outer sheath as outer electrode for testing the sheath.
17.	Approximate Length of cable in a drum	500 metres with a tolerance range of ±5% or as per requirement.
18	Bending Radius	The minimum bending radius of XLPE insulated cables as follows: Cable: Bending radius Single Core: 25xD D – diameter of overall conductor.
19	**TESTS** Applicable standards	IEC60840 IEC62067
19.1	Type Test a)whether previous test reports will be sufficient b)whether sample to be Type tested against this order.	All tests as per specifications IEC Standards Yes, if done on identical cable. No, if done on identical cable.
19.2	Routine Test	All tests as per specifications IEC Standards.
19.3	Acceptance Test	All tests as per specifications IEC Standards.
19.4	Whether test will be witnessed by purchaser or his representative	Yes. Acceptance test will be witnessed.
20	**INSTALLATION, TERMINATION AND JOINTS**	
21	Ambient temperature Ground temperature Thermal resistivity of soil	45^0C 30^0C 150^0C cm/Km
22	Laying Configuration	Trefoil formation.
23	Depth	1.5 m below ground level.

24	Termination	
25	Type	**AS per requirement**
26	Joints Required	**No**
27	Earth Link Boxes Required	**Yes. In both end and at joints as per cable bonding system**
28	Surge Suppressor Required	**Yes**
29	Type Bonding '	**Single end bonding/ cross bonding**

3.21 TECHNICAL SPECIFICATION OF POWER AND CONTROL CABLES

3.21.1 GENERAL REQUIREMENT

1.1.0 Aluminium conductor XLPE insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.

1.1.1 For all control/protection/instrumentation purposes PVC insulated armoured control cables of minimum 1.5/2.5 sq. mm Size with stranded Copper conductors shall be used.

1.1.2 Cables shall be laid conforming to IS: 1255.

1.1.3 While preparing cable schedules for control/protection purpose following shall be ensured:

- Separate cables shall be used for AC & DC.
- For different cores of CT & PT separate cable shall be used.
- At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C sizewhereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.1.4 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.

1.1.5 Standard technical data sheets for cable sizes up to and including 1100V are enclosed.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.

3.21.2 TECHNICAL REQUIREMENTS

1.2.0 General

1.2.0.1 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.

1.2.0.2 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.

1.2.0.3 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape beforestranding 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.

1.2.0.4 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.

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

1.2.0.6 Strip wire armouring method shall not be accepted for any of the cables. For control, cables only round wire armouring shall be used.

1.2.0.7 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and atemperature index of not less than 250°C.

10.2.1.8 All the cables shall pass fire resistance test as per IS:1554 (Part-I)
10.2.1.9 The normal current rating of all PVC insulated cables shall be as per IS:3961.
10.2.1.10 Repaired cables shall not be accepted.
10.2.1.11 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

3.21.3 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.

3.21.4 PVC Power Cables

3.21.4.1 The PVC (85°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 85°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-C 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-2 of IS 5831 for all cables.

3.21.5 PVC Control Cables

3.21.5.1 The PVC (85°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 C 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-2 of IS: 5831 and shall be grey in colour.

3.21.5.2 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).

CABLE DRUMS

4.1 Cables shall be supplied in returnable wooden or steel drums of heavy construction. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum.
Drums offered shall conform to relevant standards. Drum drawings are not required to be submitted for approval.

4.2 Standard lengths for each size of power and control cables shall be 500/1000 meters. The cable length per drum shall be subject to a tolerance of plus or minus 5% of the standard drum length. The owner shall have the option of rejecting cable drums with shorter lengths. Maximum, One (1) number non standard length of cable size(s) may be supplied in drums for completion of project.

4.3 A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

4.4 A clear space of at least 40 mm shall be left between the cables and the lagging.

4.5 Each drum shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

4.6 Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation and erection.

TYPE TESTS

5.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IS.
5.2 ***XLPE INSULATED POWER CABLES (For working voltages up to and including 1100V) :-***
5.2.1 Following type tests (on one size in a contract) as per IS: 7098 (Part 1) – 1988 including its amendments shall be carried out as a part of acceptance tests on XLPE insulated power cables for working voltages up to and including 1100 V:
a) Physical tests for insulation
i) Hot set test
ii) Shrinkage test
b) Physical tests for outer sheath
i) Shrinkage test
ii) Hot deformation
iii) Heat shock test
iv) Thermal stability
5.2.2 Contractor shall submit type test reports for the following tests
a) Water absorption (gravimetric) test.
b) Ageing in air oven
c) Loss of mass in air oven
d) Short time current test on power cables of sizes 240 sqmm and above on
i) Conductors.
ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

5.3 ***PVC/XLPE INSULATED POWER & CONTROL CABLES (For working voltages up to and including 1100V)-***

5.3.1 Following type tests (on one size in a contract) as per IS: 1554 (Part 1) -1988 including its amendments shall be carried out as a part of acceptance tests on PVC insulated power & control cables for working voltages up to and including 1100 V:

a) Physical tests for insulation and outer sheath
i) Shrinkage test
ii) Hot deformation
iii) Heat shock test
iv) Thermal stability
b) High voltage test (water immersion test only a.c. test as per clause no. 16.3.1).

5.3.2 Contractor shall submit type test reports for the following

a) High voltage test (water immersion d.c. test as per clause no. 16.3.2 of IS: 1554 (Part 1) - 1988).
b) Ageing in air oven.
c) Loss of mass in air oven.
d)Short time current test on power cables of sizes 240 sqmm and above on
i) Conductors.
ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

10.3 DATA SHEET FOR CABLES

(A) 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: 7098/PT-I & itsreferred standards	
2	Type Designation	A2XWY	A2XWY	A2XWY
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 4 (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 successivelayers		
7	Insulation			
	a) Composition of insulation	Extruded XLPE asper IS-7098 Part(1)	Extruded XLPE as per IS-7098 Part(1)	Extruded XLPE asper IS-7098 Part(1)
	b) Thickness of insulation(mm)	As per applicable Standard		
8	Inner Sheath material	Extruded PVC type ST-2 as perIS-5831	Extruded PVC type ST-2as per IS- 5831	
9	Type and material of armour	Gal. Steel wire	Gal. Steel wire	Gal. Steel wire
10	Outer Sheath (PVC)	ST-2 & FR	ST-2 & FR	ST-2 & FR
11	Overall diameter of cable	As per applicable Standard		

(B) 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 C 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
9	Type and material of armour	Gal. Steel wire
10	Outer Sheath (PVC)	ST-2 & FR
11	Overall diameter of cable	As per applicable Standard
12	No. of Cores	As per Bill of Materials

CHAPTER 3.22: TECHNICAL SPECIFICATION FOR 220kV, 132KV CIRCUIT BREAKER (AIS)

22.1.0. SCOPE

22.1.1. The intention of this Section of the Specification is to cover design, manufacture, testing at manufacturer's works and of 220kV, 132kV Circuit Breakers with all fittings and accessories including mounting structures as specified hereunder.

22.2.0. GENERAL REQUIREMENTS

22.2.1. The circuit breaker shall be of three phase unit (gang operated) (or) three identical single-phaseunits (as said in data sheet), outdoor**, SF6 gas filled** single pressure puffer type(220kV, 132kV and 66kV)and VCB for 33kV. The operating mechanism shall be electrically and mechanically trip/free with anti-pumping facility suitable for remote electrical closing, tripping as well as local Operation facility as specified. The CBs are meant for installation with Transformers & **Lines and capacitor banks as applicable.**

22.2.2. The circuit breaker shall be capable of 3-ph auto-reclosing.

22.2.3. The circuit breaker shall be so designed to withstand the effects of temperature, wind load, short circuit, **seismic conditions** and other adverse conditions.

22.2.4. The circuit breaker shall be capable of switching transformer magnetizing currents and shall be restrike - free.

22.2.5. All similar parts, particularly removable ones, shall be interchangeable with one another.

22.2.6. All cable ferrules, lugs, tags, etc. required for cabling from equipment control cabinet/operating mechanism to the central control cabinet of the breaker shall be supplied loose as per approved schematics.

22.2.7. The SF6 breaker shall be designed to ensure that condensation of moisture is controlled **by proper selection of organic insulating materials having low moisture absorbing characteristics**

22.2.8. The support structure of circuit breaker shall be hot dip galvanised. Sufficient galvanising thickness shall be achieved with **900 gm/m² (130 micron).** All other parts shall be painted as per painting specification enclosed separately.

22.2.9. All mechanical parts and linkages shall be robust in construction and maintenance free over at least 10,000 switching operations except for lubrication of pins/articulated joints at 5000 operations **and electrical E2 performance**.

22.3.0. OPERATING MECHANISM

22.3.1. A power spring operated mechanism for closing and tripping shall be provided in the breaker control cabinet. This device shall be so interlocked that while it is under maintenance, the breaker cannot be operated from remote. A slow acting, manually operated device shall be provided for inspection and maintenance purposes.

22.3.2. Circuit breaker operating mechanism shall be capable of storing energy for at least two complete closing and tripping operations.

22.3.3. Each mechanism shall have an operation counter.

22.3.4. The operating mechanism shall be trip-free and mounted and enclosed in a weather- proof, vermin-proof, sheet steel cabinet conforming to IP: 55 degree of protection. Sheet steel thickness shall be as specified in data sheet. The cabinet shall also house relays, control and auxiliary equipment of each breaker and provision for terminating all control, alarm and auxiliary circuits. It shall be provided with hinged doors with provision for locking and removable gland plates to be drilled at site. Inspection window shall be provided for observation of the instruments without opening the cabinet. It shall be mounted so as to provide convenient access from ground level. **Two trip coils shall be provided.**

22.3.5. The cabinet shall be fitted with a thermostatically controlled anti-condensation heater, a 15A, 1 phase, 5 pin socket outlets with switch and a cubicle illuminating lamp suitable for operation on 240 V AC 50Hz supply.

22.3.6. Circuit breakers shall feature high repeatability of absolute closing time over a wide range of parameters (ambient temperature, pneumatic pressure, control voltages, etc).

22.3.7. Main poles shall operate simultaneously. There shall be no objectionable rebound and the mechanism shall not require any critical adjustment. It shall be strong, rigid, positive and fast in operation.

22.3.8. **Pole discrepancy** shall be provided which shall detect pole position discrepancy.

22.3.9. The design of the circuit breaker shall be such that contacts will not close automatically upon loss of gas/ air pressure.

22.3.10. Closing release shall be capable of operating within the range of the rated voltage as specified in the data sheet. Shunt trip shall operate satisfactorily under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker within the range of the rated voltages specified in the Data sheet.

22.3.11. 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 or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

22.3.12. All controls, gauges, relays, valves, hard drawn copper piping and all other accessories as necessary shall be provided including the following:

22.3.13. Low pressure alarm and lock out relay with adjustable pressure setting suitable for operation on DC system

22.3.14. A no-volt relay for remote indication of power failure for compressor motor/ Spring Charge motor.

22.3.15. As long as power is available to the motor, continuous sequence of closing and opening operations shall be possible.

22.3.16. After failure of power supply to the motor, at least **two close-open** operation of the circuit breaker shall be possible from stored energy.

22.3.17. Spring charging motor shall be standard single phase universal motor suitable for 220 volts supply for Rangia GIS and 110volts for Nalbari GSS.

22.3.18. Motor rating shall be such that it requires only about 30 seconds for full charging of the closing spring.

22.3.19. Closing action of the circuit breaker shall compress the opening spring ready for tripping.

22.3.20. During closing, springs are discharged and after closing of breaker, springs shall automatically be charged for the next operation. Facility for manual charging of closing springs shall be provided. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

22.4.0. OPERATING MECHANISM CONTROL

22.4.1. The breaker shall normally be operated by remote electrical control. However, provision shall be made for local electrical control. For this purpose, a local/remote selector switch, close and trip control switch/push button shall be provided in the breaker central control cabinet.

22.4.2. Two electrically independent trip circuit including two trip coils per breaker shall be operated from two separate DC sources. First trip coil shall be utilized for tripping the breaker on main protection fault detection. Whereas second trip coil shall be used to trip the breaker when first trip coil fails to trip the breaker and backup protection comes into operation and shall also be used to trip the breaker on command.

22.4.3. The trip coils shal be suitable for trip circuit supervision during both **open and close position** of the breaker. Necessary terminals shall be provided in the central control cabinet of the circuit breaker by the supplier.

22.4.4. The auxiliary switch with **12NO+12NC** contacts of the breaker shall be positively driven by the breaker operating rod.

22.4.5. A conveniently located manual tripping lever or button shall also be provided for local tripping of the breaker and simultaneously opening the reclosing circuit. A local manual closing device which can be easily operated by one

man standing on the ground shall also be provided for maintenance purpose. Direction of motion of handle shall be clearly marked.

22.4.6. When the spring get fully charged either through motor or hand cranking, the spring charging motor and the hand cranking **suitable mechanical and electrical indication shall be provided for same. On restoration of electrical supply the mechanical handle shall be automatically disengaged.**

22.5.0. SF6 GAS SYSTEM

22.5.1. SF6 gas shall serve as an arc-quenching medium during opening/closing operation and as an insulating medium between open contacts of the circuit breaker.

22.5.2. The circuit breaker shall be single pressure **puffer** type. The design and construction of the circuit breaker shall be such that there is a minimum possibility 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.

22.5.3. All gasketed surfaces shall be smooth, straight and reinforced, if necessary, to minimise distortion and to make a tight seal, the operating rod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. The SF6 gas leakage should not exceed 1% per year

22.5.4. 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 such as fully compatible with SF6 gas decomposition products.

22.5.5. Each pole shall form an enclosure filled with SF6 gas independent of two other poles (145 and 66 kV CBs) and the SF6 density of each pole shall be monitored.

22.5.6. The dial type SF6 density monitor shall be adequately temperature compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. The density monitor shall have graduated scale and shall meet the following requirements:

- 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.

22.5.7: SF6 gas shall be as per IEC 60376

22.6.0. VACUUM INTERRUPTER ASSEMBLY

22.6.1. Each pole of the circuit breaker shall be provided with vacuum interrupter, one for each phase, hermetically sealed for life and encapsulated by ceramic insulators. The interrupter shall be provided with steel chromium arc chamber to prevent vaporized contact material being deposited on the insulating body. A further shield giving protection to the metal bellows shall also follow the travel of the moving contacts to seal the interrupter against the surroundings atmosphere.

22.6.2. It shall have high and consistent dielectric strength of vacuum unaffected by environment and switching operations. Bronzed joints should ensure retention of vacuum for life time. It shall have low and stable contact resistance due to absence of oxidation effects and shall ensure low power loss. The arcing voltage shall be low and minimum contact erosion

22.7.0. BUSHINGS AND INSULATORS

22.7.1. 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.

22.7.2. 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.

22.7.3. 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.

22.7.4. Bushings shall satisfactorily withstand the insulation level specified in data sheet.

22.8.0. FIXED AND MOVING CONTACTS

22.8.1. Main contacts shall have ample area and contact pressure for carrying the rated current and the short time rated current of the breaker without excessive temperature rise which may cause pitting or welding. Contacts shall be adjustable to allow for wear, easily replaceable and shall have minimum moving parts and adjustments to accomplish these results. Main contacts shall be the first to open and the last to close so that there will be little contact burning and wear out.

22.8.2. Arcing contacts, if provided, shall be the first to close and the last to open and shall be easily accessible for inspection and replacement. Tips of arcing and main contacts shall be silver faced.

22.8.3. If multi-break interrupters are used, they shall be so designed and augmented that a fairly uniform voltage distribution is developed across them.

22.9.0. INTERLOCKS

22.9.1. Key release mechanical interlocks shall be incorporated in the operating mechanism for interlocking with the associated isolators, so that operation of the circuit breaker is dependent on a "key-trapped" situation. In addition, electrical interlocks with associated isolators shall be provided.

22.10.0. ADDITIONAL DUTY REQUIREMENTS

22.10.1. Circuit breakers shall be capable of clearing short line faults with the same impedance behind the bus corresponding to the rated fault current.

22.10.2. Circuit breakers shall be capable of breaking 25% of rated fault current at twice rated voltage under out of phase conditions.

22.10.3. The Bid shall highlight the design features provided to effectively deal with:

a) Breaking of inductive currents and capacitive currents.
b) Charging of long lines and cables.
c) Clearing developing faults within the full rating of the breaker.
d) Opening on phase opposition.

22.11.0. ACCESSORIES

22.11.1. **Gas Pressure Detector**

The circuit breaker shall be provided with gas pressure monitor with temperature compensation for initiating alarm and locking the operating mechanism in the event of abnormality. **Gas pressure monitor shall be combined for all three phases for (220kV, 145kV and 66kV) Circuit Breakers. Each phase of Circuit Breaker shall be provided with pressure gauge with Red and Green zone and pressure level marked on the dial.**

22.11.2. **Position Indicator**

Each pole of the circuit breaker shall be provided with a position indicator.

22.11.3. **Terminals**

Each circuit breaker shall be provided with suitable terminal pads of high conductivity aluminium alloy for connecting to the line.

22.11.4. **Auxiliary Switches**

Each circuit breaker shall be equipped with auxiliary switches with sufficient number of contacts for control, indication and interlocking purposes. Twelve normally open and twelve normally closed contacts shall be provided as spares. All contacts shall be rated for the DC voltage specified in data sheet.

22.11.5. **Terminal Blocks**

All accessories, spare contacts of contactors and control devices shall be completely wired up to terminal block. All wirings which are connected to external circuit shall be terminated on terminal blocks installed in the control cabinet. The terminal blocks provided shall have twenty (20) percent spares. **Each terminal block shall be suitable to receive two conductors of minimum 2.5sqmm copper.**

22.11.6. Operating mechanism housing shall be supplied with all required accessories including the following:

a) Padlocks and duplicate keys.
b) Space heaters equipped with automatic thermostatic control.
c) Local/remote changeover switch.
d) Manually operated tripping push button/lever (mechanical) conveniently located to trip all three phases simultaneously.
e) Control switches to cut off control power supplies.
f) Fuses as required.
g) Two earthing terminals.
h) Auxiliary relays required for satisfactory operation.
i) Motor contactor with thermal release
j) Provision for mechanical interlock with isolator.
k) Indication Lamps for On/OFF operation

22.11.06:

22.12.0. SUPPORT STRUCTURES

22.12.1. The Circuit Breakers shall be suitable for mounting on steel structures.

22.12.2. The support structure shall be of steel hot dip galvanised type. The height of support structure shall be designed to keep the bottom most live part and bottom of insulators of circuit breakers at minimum clearance from the plinth as specified in data sheet.

22.12.3. All necessary galvanised bolts, nuts and washers to complete the erection shall be furnished including the embedded anchor bolts for securing the supporting structure to the concrete foundations.

22.12.4. **The support structures shall be capable to withstand the minimum seismic acceleration of 0.36 g in horizontal direction and 0.6g in vertical direction.**

22.13.0. NAME PLATES

22.13.1. 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.

22.14.0. EARTHING

22.14.1. Two earthing pads shall be provided on each supporting structure. Each operating mechanism control cabinet or terminal box mounted on the supporting structure shall also be connected to an earthing pad. Separately mounted control cabinets shall be provided with two earthing pads adjacent to the base of the cabinet. The earthing connection shall be bolted type and suitable for receiving **75mm x 12mm GS strip.**

22.15.0. TERMINAL CONNECTORS

22.15.1. The equipment shall be supplied with required number of terminal connectors of approved type suitable for ACSR conductors. 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.

22.16.0. TESTS

22.16.1. All routine tests shall be carried out in accordance with relevant IS. All routine/acceptance tests shall be witnessed by the AEGCLs authorised representative. The tests shall include the following:

a) Routine/Acceptance Tests (all units) i)Mechanical Operation tests

ii)Power frequency voltage withstand test (dry) iii)Tests on auxiliary & control circuits

iv) Measurement of resistance of the main circuit.

v) Insulation Resistance Test

b)Type Tests:

The bidder shall furnish type test certificates and results for the following tests along with the bid for breaker of identical design.

i) Breaking(terminal fault, L90,etc) and making capacity test

ii) Short-time current withstand test

iii) Temperature rise tests

iv) Lightning Impulse voltage test

v) Operating Duty test

vi) Pole Discrepancy test

vii) Power Frequency withstand test

viii) IP degree of protection of operating mechanism enclosure

ix) RIV/PD test

x) Contact Resistance of CB

xi) IR value test for operating mechanism circuits

xii) Creepage distance test

c) **Test Certificates**

Copies of routine/acceptance test certificates shall be produced with the endorsement of the inspecting authority to the Employer before effecting despatch. The test report shall contain the following information.

i) Complete identification data, including serial No. of the breaker.

ii) Method of application, where applied, duration and interpretation of results in each test.

22.17.0. PRE-COMMISSIONING TESTS

22.17.1. 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 approved document of the equipment AEGCL without any extra cost to the AEGCL. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to AEGCL for approval.

(a) Insulation resistance of each pole.

(b) Check adjustments, if any suggested by manufacturer.

(c) Breaker closing and opening time.

(d) Slow and Power closing operation and opening.

(e) Trip free and anti-pumping operation.

(f) Minimum pick-up voltage of coils.

(g) Contact resistance measurement.

(h) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.

(i) Insulation resistance of control circuits, motor etc.

(j) Resistance of closing and tripping coils.

(k) SF6 gas leakage check.

(l) Dew Point Measurement

(m) Verification of pressure switches and gas density monitor.

(n) Checking of mechanical 'CLOSE' interlock, wherever applicable.

(o) Testing of grading capacitor.

(p) Resistance measurement of main circuit.

(q) Checking of operating mechanisms

(r) Check for annunciations in control room.

(s) **Sniffer test of VCB**

22.18.0. SPECIAL TOOLS AND TACKLES

22.18.1. The Bidder shall furnish a list of any special tools and tackles required for maintenance and operation purposes with recommended quantities for each substation.

22.19.0. TECHNICAL DATA SHEET FOR CIRCUIT BREAKER

Sl. No.	Particulars	Unit	Data for 132kV CB	Data for 220kV CB	Data for 33 kV CB
I	II	III	IV	V	VI
1	Type		SF_6	SF_6	VCB
2	No of poles		3 (3 Phase Ganged Unit)	3 (3 Phase Ganged Unit)	3 (3 Phase Ganged Unit)
3	Service		Outdoor	Outdoor	Outdoor
4	Rated System Voltage	kV	132	220	33
5	Highest System Voltage	kV	145	245	36
6	System earthing		Solidly earthed system	Solidly earthed system	Solidly earthed system
7	Rated Voltage of Breaker	kV	145	245	36
8	Rated Continuous Current	Amps	**As per approved SLD**		
9	Rated Frequency	Hz	50	50	50
10	Rated Short Circuit breaking current (I) - 3secs - symmetrical	kA RMS	40	**50**	31.5
11	Rated Short Circuit making current	kA PEAK	2.5*I	2.5*I	2.5*I
12	Duty cycle		0-0.3 Sec - CO -3 Min -CO	0-0.3 Sec - CO -3 Min -CO	0-0.3 Sec - CO -3 Min -CO
13	First pole to clear factor		1.3	1.3	1.3
14	Operating time				

Sl. No.	Particulars	Unit	Data for 132kV CB	Data for 220kV CB	Data for 33 kV CB
I	II	III	IV	V	VI
	i) Opening Time	ms	Not exceeding 50 ms	Not exceeding 50ms	Not exceeding 50 ms
	ii) Closing Time D	ms	**Not exceeding** 100 ms	**Not exceeding 100 ms**	Not exceeding **100 ms**
15	Insulation level i) One minute Power Frequency withstand Voltage (Dry) ii) Full Wave Impulse withstand Voltage (1.2/50 µsec)	 kV RMS kV Peak	 275 650	 460 1050	 75 170
16	Minimum clearance between phases	mm	1300	As per IS	320
17	Minimum clearance between phase to earth	mm	1300	As per IS	320
18	Minimum Ground clearance (from bottom most live part to plinth level)	mm	4600	5500	3700
19	Minimum clearance from bottom of support insulator to plinth level	mm	2500	2500	2500
20	i) Minimum Creepage Distance (Total)	mm	4495	7595	1116
	ii) Minimum Creepage Distance (Protected)	mm	2250		460
21	Operating mechanism a) Type		Spring Charged	Spring Charged	Spring Charged
	b) Rated 3 Phase, 50Hz Voltage for Drive Motor	V	220AC	220AC	220AC
	c) Rated voltage of Shunt trip coil & operating range	V. DC	220 or110[50% - 110%]	220 or110[50% - 110%]	220 or 110 [50% - 110%]
	d) Rated voltage of Closing coil & operating range	V. DC	220 or 132 [80% - 110%]	220 or 132 [80% - 110%]	220 or 132 [80% - 110%]
	e) No. of trip coils	No	2 per CB	2 per CB	2 per CB
	f) No. of closing coils	No	1 per CB	1 per CB	1 per CB
	g) No of spare auxiliary contacts & contact rating	Nos AMPS	12 N/O+12 N/C (per CB) 10 A at 240V AC & 4A at 220V/ 110V DC	12 N/O+12 N/C (per CB) 10 A at 240V AC & 4A at 220V/ 110V DC	12 N/O+12 N/C (per CB) 10 A at 240V AC & 2A at 220V/ 110V DC
	h) Minimum thickness of steel sheet for control cabinet	mm	3	3	3
	i) Enclosure Protection		IP55	IP55	IP55
22	Reclosing		Three Phase auto reclosing	Three Phase auto reclosing	Three Phase auto reclosing
23	Support structure (Painted / Galvanised)		Galvanised	Galvanised	Galvanised

Sl. No.	Particulars	Unit	Data for 132kV CB	Data for 220kV CB	Data for 33 kV CB
I	II	III	IV	V	VI
24	All other parts (Painted / Galvanised)		Synthetic enamel shade 631 of IS5 (125 microns)	Synthetic enamel shade 631 of IS5 (125 microns)	Synthetic enamel shade 631 of IS5 (125 microns)
25	Minimum size of control wiring (Copper)	Sq. mm	2.5	2.5	2.5
26	ITRV and TRV of CB interrupter		IEC	IEC	IEC

3.23: TECHNICAL SPECIFICATION FOR 220kV, 132KV CURRENT TRANSFORMERS (AIS)

23.1.0 SCOPE OF CONTRACT

This Section of the Specification covers general requirements for design, engineering, manufacture, assembly and testing at manufacturer's works of 220kV, 132kV outdoor Current Transformers.

23.2.0 STANDARDS

23.2.1 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.

23.2.2 In case of any conflict between the Standards and this specification, this specification shall govern.

23.2.3 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.
(V)	**All relevant IEC**	

23.3.0 GENERAL REQUIREMENTS

23.3.1 The cores of the instrument transformers shall be of high grade, non-aging CRC steel of low hysteresis loss and high permeability.

23.3.2 Current transformers shall be of Live Tank design.

23.3.3 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 are requested to quote the current transformers with stainless steel diaphragm (bellow).

23.3.4 The instrument transformers shall be completely filled with oil.

23.3.5 A complete leak proof shrouded secondary terminal arrangement shall be provided with instrument transformers, secondary terminals 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. **CT secondary shorting links shall**

be provided along with one terminal earthing arrangement of CT winding. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement.

23.3.6 All instrument transformers shall be of single phase unit.

23.3.7 The instrument transformers shall be so designed to withstand the effects of temperature, wind load, short circuit conditions and other adverse conditions.

23.3.8 All similar parts, particularly removable ones, shall be interchangeable with one another.

23.3.9 All cable ferrules, lugs, tags, etc. required for identification and cabling shall be supplied complete for speedy erection and commissioning as per approved schematics.

23.3.10 The instrument transformers housing shall be porcelain.

23.3.11 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.

23.3.12 Test terminal for tan-delta/capacitance shall be provided for CT's.

23.3.13 Accuracy specified shall be maintained at 25% of rated burden.

23.3.14 All winding(Primary/Secondary) shall be of copper. Aluminium is not acceptable

23.4.0 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

23.5.0 COMMON MARSHALLING BOXES (shall be supplied by CT manufacturer)

23.5.1 The outdoor type common marshalling boxes shall conform to the latest edition of IS 5039 and other general requirements specified hereunder.

23.5.2 The common marshalling boxes shall be suitable for mounting on the steel mounting structures of the instrument transformers.

23.5.3 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.

23.5.4 The enclosures of the common marshalling boxes shall provide a degree of protection of not less than IP 55 (As per IS 2147).

23.5.5 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.

23.5.6 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.

23.5.7 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. All terminals of control circuits shall be wired up to marshalling box including spare terminals evenly distributed on all TB's.

23.5.8 All terminal strips shall be of isolating type terminals and they will be of minimum 10 A continuous current rating.

23.5.9 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.

23.5.10 Each common marshalling box shall be provided with two numbers of earthing terminals of galvanised bolt and nut type.

23.5.11 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)

23.6.0 BUSHINGS AND INSULATORS

23.6.1 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 **and shall conform to IEC 60135, 60168/IS.**

23.6.2 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.

23.6.3 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. No radio interference shall be caused by the bushings when operating at the normal rated voltage

23.6.4 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.

23.6.5 Sharp contours in conducting parts should be avoided for breakdown of insulation. The insulators shall be capable to withstand the minimum seismic acceleration of 0.5 g in horizontal direction and 0.6g in vertical direction..

23.6.6 Bushings shall satisfactorily withstand the insulation level specified in data sheet.

23.6.7 Rain shed/drain cover/dome shall be present in CT.

23.6.8 Bellow level indicator shall be present in CT.

23.6.9 Nitrite butyl rubber/Neoprene gaskets shall be used.

23.6.10 Critical flashover voltage of insulator and bushing shall be provided.

23.7.0 TESTS

23.7.1 **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.

23.7.2 **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.

23.7.3 **QAP:** QAP indicating all brought out materials tests shall be submitted.

23.8.0 NAME PLATES

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.

23.9.0 MOUNTING STRUCTURES

23.9.1 All the equipment covered under this specification shall be suitable for mounting on steel structures. Supply of mounting on **galvanised** structures is also in the scope of this tender.

23.9.2 Each equipment shall be furnished complete with base plates, clamps, and washers etc. and other hardware ready for mounting on steel structures.

23.10.0 SAFETY EARTHING

23.10.1 The non-current carrying metallic parts and equipment shall be connected to station earthing grid with two terminals.

TERMINAL CONNECTORS (Shall be under manufacturer scope)

23.11.1 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 AEGCL, as per installation requirement while approving the equipment drawings. No part of a clamp shall be less than 12mm. thick. All connectors shall be of Aluminium Alloy and type tested as per IEC/IS including RIV and short circuit.

PRE-COMMISSIONING TESTS

23.12.1 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).

(ix) Knee-point voltage measurement

23.13.0 TECHNICAL DATA SHEET FOR CURRENT

23.13.1 For 220/**145/72.5/**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 upto the terminal blocks.

23.14.0 TYPE AND RATING:

23.14.1All 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.

SL No.	A. Item		Ratings and Particulars	
I	II	III	IV	
A	Nominal system voltage	132 kV	220 kV	66 kV
B	Highest system voltage, kV	145	245	72.5
C	Rated frequency, HZ	50	50	50
D	System earthing	Solidly earthed	Solidly earthed	Solidly earthed
E	Insulation level			
a)	Full Wave Impulse withstand voltage: kVp (1.2/50)	650	1050	325

b)	One-minute p.f. Withstand voltage, kV (r.m.s.) (dry and wet)	275	460	140
F	Short time current for 3 seconds, kA	40	50	31.5
G	Minimum creepage distance, mm	4495	7595	2247.5
H	Temperature rise	As per IS	As per IS	As per IS
I	**C.T.**			
	(i) No. of Cores	5	5	5
	(ii) Transformation ratio	As per approved SLD		
	(iii) Rated out put			
	(a) Core-1	20 VA	20 VA	20 VA
	(b) Core-2	20 VA	20 VA	20 VA
	(c) Core-3	(PX CLASS)	PX (for trafo only)	PX
	(d) Core-4	(PX CLASS)	PX (for trafo only)	PX
	(e) Core-5	(PX CLASS)	PX (for trafo only)	PX
	(iv) Accuracy class			
	(a) Core-1	0.2S	0.2S	0.2S
	(b) Core-2	5P20/PX (trafo)	5P20/PX (trafo)	5P20
	(c) Core-3	PX	PX (for trafo only)	PX
	(d) Core-4	PX	PX (for trafo only)	PX
	(e) Core-5	PX	PX (for trafo only)	PX
	(vi) Instrument security factor			
	(a) Core-1	<5	<5	<5
	(b) Core-2	-	-	-
	(c) Core-3	-	-	-
	(d) Core-4	-	-	-
	(e) Core-5	-	-	-
	(vii) Minimum Knee point voltage, Volts			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min

	(d) Core-4	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(e) Core-5	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(viii) Maximum secondary resistance, ohm			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	<3	<3	<3
	(d) Core-4	<3	<3	<3
	(e) Core-5	<3	<3	<3
	(ix) Maximum exciting current, at Vk/4 mA			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	-	-	-
	(d) Core-4	-	-	-
	(e) Core-5	-	-	-
	Tandelta at Um/ root 3	< 3	< 3	< 3
	Rated extended primary current	120%	120%	120%

Note:

(i) 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.

(ii) The knee point voltage specified above shall be at higher ratio/ taps.

(iii) CT and PT sizing calculations shall be submitted. Burden values and knee point voltage, shall be decided as per the calculations during detailed engineering

(iv) For Station service bay equipments rated system voltage shall be 33kV and highest system voltage shall be 72.5kV.

CHAPTER 3.24: TECHNICAL SPECIFICATIONS OF POST INSULATORS

3.24.1 The post insulators shall conform in general to latest IS: 2544, IEC-60168, IEC60273 and IEC-60815.

3.24.2 Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable. **Conical design insulator shall not be accepted**.

3.24.3 Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

3.24.4 Glazing of the porcelain shall be of uniform brown in colour, free from blisters, burrs and other similar defects.

3.24.5 All ferrous parts shall be hot dip galvanised in accordance with the latest edition of IS: 2633, & IS: 2629. The zinc used for galvanising shall be grade Zn 99.95 as per IS: 209. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulk white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.

Sl. No	Parameters	400 kV	220 kV	132 kV	33 KV
1	Type	Solid Core	Solid Core	Solid Core	Solid Core
2	Highest system voltage	420 kV	245 kV	145 kV	36 kV
3	Dry one minute power frequency test voltage	680 kV	510 kV	275 kV	75 kV
4	Dry Impulse voltage withstand test	1425 kV	1050 kV	650 kV	170 kV
5	Wet switching surge withstand voltage (kVp)	±1050	-	-	-
5	Minimum Creepage Distance	13020 mm	7595 mm	4495 mm	1116 mm
6	Minimum Bending Strength (upright)	10 kN	8 kN	6- kN	4-kN

Note: Cantilever strength may be higher as per EDF calculations to be carried out by the successful bidder during detailed engineering

CHAPTER 3.25: TECHNICAL SPECIFICATION OF CONTROL AND RELAY PANEL

3.25.1 TECHNICAL SPECIFICATIONS FOR CONTROL & RELAY PANELS:

a) This Section is intended to cover the design, manufacture, assembly, testing at manufacturer's works and erection, testing & commissioning of Indoor Relay and Control Panels.

b) The Control and Relay Panels required are for control and protection of the Power Transformers and Feeders according to requirements. The supply shall include all accessories, special tools, supporting steels, spare parts, drawings, relevant software, instruction manuals etc. The panels shall be supplied complete with all accessories as specified and completely assembled and all internal wiring completed.

c) The sub-stations shall have automation as per IEC 61850 protocol in Bay & Station level. The bidder has to supply the C&R panels to match the requirement of Sub-station Automation System (SAS) as specified in the subsequent chapter, **from the same manufacturer**.

d) **The manufacturer/supplier of Control and Relay Panels shall necessarily be an OEM (Original Equipment Manufacturer) of Numerical Protective Relays, Bay Control Units and Sub Station Automation System (SAS), having registered servicing unit in India.**

e) Design and fabrication of Control & Protection Panels for mounting the relay and relay assemblies along with all necessary accessories like switches, indicating lamps etc. and wiring up of the same to provide self contained and ready to use protection as per this specification.

f) Complete testing at manufacturer's works of the relays and protection schemes **including SAS** after mounting and fully wiring up in the Control & Protection Panels.

2.25.2 STANDARDS:

All equipment and all component parts supplied under this specification shall conform in all respects to the latest issue of relevant IEC and Indian Standard Specifications except where specified otherwise in this specification. Equipment meeting any other authoritative standards which ensure an equal or better quality may also be acceptable.

3.25.2 SERVICE CONDITIONS:

The plant and materials supplied shall be suitable for operation under the following climatic and other conditions as mentioned in chapter 2 of this Bid document:

3.25.4 TYPE TEST REPORTS.

3.25.5 Equipment, 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.

3.25.6 All Bids must be accompanied by the full Type Test Certificates of equipment offered. Such type test certificates shall be acceptable only if:

i) Tests are conducted in KEMA/NABL accredited laboratory, *for GOOSE messaging etc as per relevant IEC 61850 Standards.*

ii) Inter-operability 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 Indian clients of Central/State Transmission Utilities.

iii) The Validity of the Type Test Reports of CRP, Relays, BCUs and Energy Meters shall be as per CEA's "Guidelines for the 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).

3.25.7 TYPE OF PANEL

3.25.8 All simplex panels shall be swing type with front glass door with locking arrangement. The **Minimum number** of Panels shall be as per Table 1 below:

Table -1

	400kV	**220kV**	**132kV**	**33kV**
Feeder Panel	4 Nos if SWLR	2 Nos	2 Nos	1 No
Bus Coupler/Tie Breaker/Sectionalizer Panel	2 No	1 No	1 No	1 No
Reactor Panel	2 No			
Bus Bar Protection panel	4 Nos	2 Nos		
Transformer Panel	400/220/33kV AT	220/132kV AT	132/33kV PT	
	3Nos (Minimum)	2Nos (Minimum)	2 Nos (Minimum)	

3.25.9 Swing type Simplex Control and Relay Panels shall consist of vertical swing front panels with equipment mounted thereon and having front glass door. As there will be no rear door, manufacturer shall have to keep suitable swing angle, for maintenance & testing of equipment, circuitry inspection etc. Panel front shall have lockable glass door.

3.25.10 These panels shall be of the **Simplex type** with the following approximate dimensions:
i. Height: 2250mm + 15mm anti-vibration pad + 50 mm (base)
ii. Depth: 800mm to 1000 mm
iii. Width: 800 mm to 1000 mm
iv. Operating Height: 1800 mm

3.25.11 For 33kV feeder, panel shall be of simplex type and it should accommodate one 33kV feeder in a single cubicle and one BCU will control single 33kV feeder.

3.25.12 CONSTRUCTIONAL FEATURES:

a) The panels shall be completely metal enclosed to ensure a dust, moisture and vermin proof atmosphere. The enclosure shall provide a degree of protection not less than IP 54 in accordance with IS-2147/IEC-60529.

b) Panels shall be rigid free standing and floor mounting type and comprise of structural frames enclosed completely with specially selected texture finished, cold rolled sheet steel of thickness not less than 3.15 mm for weight bearing members of the panels such as base frame, front sheet and door frames and not less than 2.0 mm for sides, door top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation.

c) All joints shall be made flush and all edges shall be bent at right angles and rounded. All structural members shall be bolted or welded together. Necessary arrangement shall be provided for bolting together the adjacent panels as well as

for fastening them to the floor. The opening required for mounting the equipment shall be punched or cut and filed smooth.

d) All doors, removable covers and panels shall be sealed all around with synthetic rubber gaskets Neoprene/EPDM generally conforming to provision of IS 11149. However, XLPE gaskets can also be used for fixing protective toughened glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

e) Panels shall have additional rolled channel plinth at the bottom with smooth bearing surface. The panels shall be fixed on the embedded foundation channels with intervening layers of anti-vibration strips made of shock absorbing materials which shall be supplied by the contractor.

3.25.13 **MOUNTING OF EQUIPMENTS:**

a) All equipment on and in the panels shall be mounted and completely wired to the terminal blocks ready for external connection. All equipment on the front panels shall be mounted flush. Terminal markings shall be clearly visible.

b) Bay level intelligent electronic devices (IED) BPU for protection and control (BCU) and the Managed Ethernet Switch shall be housed in the C&R panels installed in the local control room.

3.25.14 **INTERNAL WIRING:**

a) Panels shall be supplied completely with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are located adjacent to each other all inter panel wiring and connections between the panels shall be furnished and wiring shall be carried out internally. These adjacent inter panel wiring shall be clearly indicated in the drawing furnished by the supplier.

b) Bay level intelligent electronic devices (IED) for protection, control (BCU) and the Managed Ethernet Switch shall be housed in the C&R panels installed in the local control room.
   i) All Circuits except instrument transformers **and incoming AC/DC Supply** circuits: 1.5 sq. mm. per lead.
   ii) Instrument transformers circuit: 2.5 sq. mm. per lead.

c) 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 panel running throughout the entire length of the panels.

d) Wire terminals shall be made with solder less clamping type of tinned copper lugs, which firmly grip the conductor and insulation. 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 wires and shall not fall off when the wire is disconnected from blocks.

e) Interconnections to adjacent panels shall be brought out to a separate set of terminals blocks located near the slots or holes meant for taking the interconnecting wires. Arrangement shall permit easy interconnection to adjacent panels at site and wires for this purpose shall be provided by the supplier looped and bunched properly inside the panel.

f) A laminated copy of total schematics is to be fixed on the inside of door.

3.25.15 **TERMINAL BLOCKS**:

a) All internal wiring to be connected to the external equipment shall terminate on terminal blocks, preferably vertically mounted on the side of each panel. Terminal blocks shall be of 1100 volts grade and have 10 amps continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Terminal block designs include a white fibre-marking strip with clear plastic/silicon chip on terminal covers. Marking on the terminal strips shall correspond to block and terminal number on the wiring diagram.

b) Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. Current transformer secondary leads shall also be provided with short-circuiting and earthing facilities.

c) At least 20% spare terminals shall be provided on each panel and these terminals shall be uniformly distributed on all terminal blocks.

d) There shall be a minimum clearance of 250 mm between first row of terminal blocks and associated cable gland plates. Also, the clearance between two rows of terminal blocks shall be a minimum of 150 mm. A steel strip shall be connected between adjacent terminal block rows at 450-mm intervals for support of incoming cables.

3.25.16 **PAINTING:**

a) All Sheet steelwork shall be phosphated in accordance with IS 6005.

b) Oil grease, dirt and warp shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

c) After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of 2 (two) coats of ready mixed, stoving type zinc chromate primer. The first coat may be 'flash dried' while the second shall be stoved.

d) After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. Exterior Paint shall be texture finishing with RAL 7032 paint shade.

e) Each coat of primer and finishing paint shall be of a slightly different shade to enable inspection of the painting.

f) The inside of the panels shall be glossy white.

g) A small quantity of finishing shall be supplied minor touching up required at site after installation.

3.25.17 **NAME PLATES AND MARKINGS:**

a) All equipment mounted on front and rear side as well as equipment mounted inside the panel shall be provided with individual nameplates with equipment designation engraved. Also, on the top of each panel on front as well as rear side large and bold name plates shall be provided for circuit /feeder designation.

b) 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 easy tracing of the wiring. The nameplates shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

c) Nameplates shall be made of non-rusting metal or 3 ply lamicord. Nameplates shall be black with white engraved lettering.

3.25.18 MISCELLANEOUS ACCESSORIES:

a) A 240 Volts, single-phase plug points shall be provided in the interior of each cubicle with ON-OFF switch for connection of headlamp.

b) Each panel shall be provided with a LED lighting fixtures for the interior illumination of the panel complete with all fittings, i.e. lamp, switch (controlled by panel door)

c) Each control panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of D.C. and A.C. supplies of various control, AC & DC supervision, signalling, lighting and space heater circuits. MCBs of requisite capacity with fail indicators shall be used, HRC fuse is not acceptable. The main input A.C. and D.C. circuits will be protected with miniature circuit breakers.

d) Pistol Grip Trip Switch shall be provided.

3.25.19 EARTHING:

a) All panels shall be equipped with an earth bus securely fixed along with inside base of the panels. The materials and the sizes of the bus bar shall be at least **25X6 mm copper.** When several panels are mounted joining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply. Provisions shall be made for extending the earth bus bar to future adjoining panels on either side.

b) All metallic cases of equipment shall be connected to the earth bus by independent copper wires of size not less than 2.5 sq. mm. Earthing wire shall be connected on terminals with suitable clamp connectors and soldering shall not be permitted.

c) PT and CT secondary neutrals or common lead shall be earthed at one place only at the terminal blocks, where they enter the panels.

3.25.20 RECORDING METERS (ABT TRIVECTOR METERS):

3.25.20.1 General

a) All meters shall be housed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. They shall be accurately adjusted and calibrated at works and shall have means of calibration, check and adjustment at site.
b) All these instruments and meters shall be flush mounted type and back connected, suitable for front panel mounting.
c) The ABT meters shall be SAMAST compatible as per specification given in subsequent chapter.
d) The meters should be compatible to IEC62052-11 and IEC62053-22, IEC62053-24, IS14697, IS15959.
e) The manufacturer shall provide Performance Certificate from CTU/STU of successful operation of minimum 3 years as on BID Opening.

3.25.20.2 RELAYS:

General

a) All relays shall conform to the requirements of IS 3231/ IEC 60255/ IEC 61000 or other relevant standards. The relay firmware/software shall be of the latest version.

b) All protective relays shall be numerical type and communication protocol shall be IEC 61850. Further, test levels of EMI as indicated IEC 61850 shall be applicable to these relays.

c) Two sets of relevant software (latest version) for relay configuration & setting, maintenance etc to be supplied to each station. The numeric relay and software shall be upgradable.

d) The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay's coils and contacts, including spare contacts.

e) Relays shall be suitable for flush or semi-flush mounting with connectors from rear.

f) All draw out cases or plug in type modular cases will have proper testing facilities. The testing facilities provided on the relays shall be specifically stated in the bid. All protective relays shall be with proper online testing facilities without isolation from TB where inputs viz CT/ PT and DC are wired. All main relays shall be provided with test plug to test the relay online & required test handle may be invariably indicated. Necessary test plug shall be in the supplier's scope of supply and shall be supplied loose. Unless otherwise specified all auxiliary relays and timers shall be supplied either in non-draw out cases or plug in type modular cases.

g) All A.C. relays shall be suitable for operation at 50 Hz. A.C. Voltage operated relays shall be suitable for 110 volts VT secondary and current operated relays for 1Amp. CT secondary. DC auxiliary relays and timers shall be designed for 110 volts/ 220 volts DC and shall operate satisfactorily between 70% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

h) All Protective relays, auxiliary relays and timers except the lockout relays and interlocking relays shall be provided with self-reset type contacts. All protective relays, trip relays and timers shall be provided with externally/ electrically reset positive action operation indicators provided with proper inscription. All protective relays which do not have built-in hand reset operation indicators shall have additional auxiliary relays with operating indicators for this purpose. Similar separate operating indicators (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as Buchholz relays, temperature protection etc.

i) No control relays that shall trip the circuit breaker when the relays are de-energized shall be employed in the circuits.

j) All relays shall withstand a test voltage of 2.5 kV, 50 Hz rms. voltage for one second. In case of static relays, the Clause 14.28.1.I shall be applicable.

k) Auxiliary seal-in unit provided in the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

(i) The operating time of the series seal-in unit shall be sufficiently shorter than that of the trip coil relay in series with which it operates to ensure definite operation of the flag indicator of the relay.
(ii) Seal - in unit shall obtain adequate current for operation when one or more relays operate simultaneously.
(iii) Impedance of the seal-in unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when D.C. supply is minimum.

(iv) Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s),but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, reclosing function etc.), and the alarm output signals.

(v)Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).

(vi)For the current seal-in method, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset and the seal in method shall not now revert to the fixed time duration method. For this seal-in method, the seal-in shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.

(vii)Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).

l) Whenever solid state auxiliary relays are used the following requirements shall be met with:

i) The printed circuit cards shall be of fibre glass type and the contact shall be gold plated. All connectors with the connector pegs shall be through wire wrapping. All solder Joints on the printed circuit boards shall be encapsulated or covered with varnish.

ii) The components shall be loaded by less than half of their rated values. The resistor shall be of carbon composition or metal oxide type and the capacitors shall be plastic film or tantalum type. Stringent measures including shielding of long internal wiring should be taken to make relays immune to voltage spikes. Relays must withstand 5kW, 1x150 microsecond, O.5 Joule source energy impulse test or 1.5 MHz damp oscillations with initial value of 2.5 kV decaying to half the initial value in 6 microseconds with internal source impedance of 150 ohms.

iii) The supplier shall ensure that the terminals of the contacts of the relays are readily brought out for connectors as required in the final approved scheme.

iv) DC /DC converter shall be provided in the solid state protective relays wherever necessary in order to provide a stable auxiliary supply for relay operation. Provision of DC cell in the protective relays as relievable stand-by power supplies will however not be acceptable.

m) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

n) All Spare pair of contacts of all IEDs and Alarm Relays shall be wired to Terminal Blocks exclusively for Employer's use.

o) All relays and their drawings shall have phase indications as R-Red, Y-Yellow, B-Blue.

p) The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

General Specification of Numerical Relays

a) Numerical Relays shall be provided for the following applications:

i) Distance Protection (Main I & Main II) of different make and model for 400KV and 220 kV lines.
ii) Distance protection for 132 kV lines.
iii) Back up directional over current and earth fault relays for 132 kV Lines.
iv) Back up non directional over current (3 O/C) and earth fault relays for 33kV lines
v) Bus Bar Protection.
vi) Integrated Numerical Transformer Differential Protection as Main –I & Main-II of different make **and model** with non-directional overcurrent and earth fault function with high set units for power and autotransformers/ reactors.
vii) Reactor Protection.

viii) *Line Differential Protection*

(viii) 3 winding transformer protection relay for Main-1 & Main-2 shall be provided for all the transformers under the scope of this bid

b) All Numerical Relays should have following minimum features.

i) Relays shall be communicable on IEC61850 protocol without any protocol converter. Certificate from KEMA confirming interoperability, Goose messaging & publishing as per IEC61850 standard shall be submitted along with the tender. The relay shall have suitable communication facility for future connectivity to SCADA.

ii) Relays shall have one no. front RJ45 or USB port (for RS 232 port Converter to USB shall be supplied for each substation along with spare) for Local Relay Parameterization and Two nos. rear FO port for connectivity to SAS over IEC61850 protocol.

iii) The relay shall have self-communication port monitoring feature and failure shall generate alarm.
iv) The relay shall have sufficient battery back up to keep the internal clock running for at least 2 years in absence of auxiliary supply. The capacitor discharging power is not sufficient and won't be accepted. Proper battery back must be provided.

v) Should have minimum 12 configurable LEDs for 132kV and above voltage class.

vi) Should have minimum **24 Binary Inputs and 32 Binary Outputs**. Moreover, the relays shall have minimum 30% BI & BO as spare after fulfilment of scheme requirement.

vi) All BI/BOs shall be site configurable

vii) Shall have front minimum 3 lines LCD display with Alpha numeric keypad.

viii) Numerical relays are to be provided with built in Event / Disturbance / Fault Recorder features.

ix) The bidder shall bring out in the bid that the Numerical relays providing different protection features / application in a single unit if any one of the application/ features goes out of service the other feature/application (s) will remain un-effected.

x) The relays shall be site configurable (Including logic development**)**

xi) Configured features & set values shall be in non-volatile memory

xii) Must have real time clock for time stamping of events/ disturbances with time synchronization inputs (GPRS etc.). Time synchronisation through SNTP compatible.

xiii) The major component cards shall be hot swappable and front or rear loading.

xiv) The relays should have self-diagnostic features identifying area of fault or failure of a particular component or card.

xv) Shall have in built Circuit Breaker Failure protection based on undercurrent detection and/or circuit breaker auxiliary contact status. Provision shall be given to initiate the breaker fail logic using a digital input from external protection devices.

xvi) Relay shall have inbuilt PRP ports.

xvii) Relays shall have redundant communication channels for Protection Communication.

c) Hardware based measurement shall not be acceptable.

d) The relay should have high immunity to electrical and electromagnetic interference.

e) The same relay shall be provided with both 1A CT inputs and shall be site selectable.

f) It shall be possible to energise the relay from either AC or DC auxiliary supply. Auxiliary dc supply shall be suitable for both 110 and 220 Volt and shall be site selectable.

g) Be capable of performing basic instrumentation functions and displaying various instantaneous parameters like Voltage, current, active power, reactive power, phase sequence etc. in primary values. Additionally, all sequence current and voltage values shall be displayed on-line. Also the direction of power flow shall be displayed.

h) Extensive disturbance recording facility shall be available for at least up to 10 seconds to capture maximum possible information. Necessary software shall be provided for retrieving and analysing the records.

i) Facility for developing customised logic schemes inside the relay based on Boolean logic gates and timers should be available. Facility for renaming the menu texts as required by operating staff at site should be provided.

j) Must have additional feature of local breaker back up protection

i) The relay shall have built in Circuit Breaker Supervision Functions.

ii) The relay shall be able to detect any discrepancy found between NO & NC contacts of breaker.

iii) The relay shall monitor number of breaker trip operations.
iv) The relay shall also monitor the breaker operating time.

k) The relays shall have the following tools for fault diagnostics:

i) Fault record (shall be function of IED): – The relay shall have the facility to store fault records with information on cause of trip, date, time, trip values of electrical parameters.
ii) Event record (shall be function of IED): – The relay shall have the facility to store time stamped event records with 1ms resolution.
iii) Disturbance records (shall be function of IED): – The relay shall have capacity to store disturbance records of at least 10 sec. duration and sampling rate per cycle shall be more than 15.

l) It shall be possible to preserve stored information in the event of an auxiliary supply failure with the help of a battery backup.

m) The relay settings shall be provided with password protection.

n) It shall be possible to change the relay setting from the front panel using the key pads/ Work station of SAS and Laptop.

o) The relay shall have comprehensive self-diagnostic feature. This feature shall continuously monitor the healthiness of all the hardware and software elements of the relay. Any failure detected shall be annunciated through an output

watchdog contact. The fault diagnosis information shall be displayed on the LCD. These records shall also be retrieved from local as well as remote terminal through the communication port.

p) The Numerical Relays shall be provided with 2 sets of common support software (latest version) compatible with latest version of Windows OS which will allow easy settings of relays in addition to uploading of event, fault, disturbance records, and measurements to Station HMI/ DR Work Station. The relay settings shall also be changed from local or remote using the same software**.**

q) In case of line protection and transformer/reactor protection, the features like fault recorder, disturbance recorder and event logging function as available (including if available as optional feature) in these relays shall be supplied and activated **at no extra cost to the owner**.

r) The manufacturer shall have to provide up-graded support software if any within 10 years span**.**

Transmission Line Protection :

Line Differential Protection Relay (If Applicable)

Main I and Main II Line Differential Protection shall be of **different make and model.**

The relay shall have all the features as per Distance protection relay over and above following features

1. It shall be working on phase segregated Current Differential protection principle.
2. It shall have multiple slope characteristic (preferably) to have stability against CT saturation and heavy through faults as well as sensitivity for internal faults.
3. It shall measure Differential as well as restrain current continuously and shall display the same as measurement.
5. It shall communicate to remote end through IEEE C37.94 format.
6. It shall have redundant communication channels for protection communication.
7. It shall communicate analogue as well as digital signals to remote end.
8. It shall have various communication options for remote communication i.e. mono-mode / multi-mode for direct communication / communication through multiplexer.
9. It shall have Line charging current compensation feature for better sensitivity.
10. Distance protection function can be utilized as independent or as back up of Differential protection in case of failure of remote communication. . It shall have a full scheme distance protection scheme to provide independent protection in parallel with the differential scheme in case of a communication channel failure for the differential scheme. The distance protection then provide protection for the entire line including the remote end back up capability either in case of a communications failure or via use of an independent communication channel to provide a fully redundant scheme of protection (that is a second main protection scheme). Eight channels for intertrip and other binary signals are available in the communication between the IEDs. The auto-reclose for single-, two- and/or three phase reclosing includes priority circuits for multi-breaker arrangements. It co-operates with the synchronism check.
11. It shall communicate time coordinated current signals for remote communication to execute Line differential protection algorithm accurately. Time synchronization through GPS shall also be possible.
12. It shall monitor individual communication links continuously and switchover to standby link after preset time in case of failure of one link.
13. It shall supervise individual telegrams.
14. It shall detect reflected telegrams.
15. It shall detect change in communication It shall measure delay time for remote end along with dynamic compensation of the same in differential protection algorithm.
17. It shall also supervise maximum permissible delay time.
18. It shall generate alarm for heavily disturbed communication link. Technical Parameters
    A. Line Differential Protection setting:
    1. Minimum operating current - 20 to 200% of In
    2. Slope (Single/dual) - 10 to 100%
    3. End section (Single/dual) - 20 to1000% of In

4. Highset operating current - 100 to 5000% of In
5. 2 nd Harmonic blocking - 5 to100 %
6. Typical operating time - 25 ms
7. Operating time for high set - 15 to 20 ms
8. Charging current comp. – Selectable

B. Remote communication:

9. Analogue signal transfer – Minimum 3 Nos.
10. Binary signal transfer - Minimum 8 Nos
11. Remote Communication module
    Dual modules suitable for
    a) 1300 nm - multi-mode
    OR
    b) 1300 / 1550 nm – mono-mode
    (finalized during detailed engineering)
12. Synchronization mode - GPS / Echo (finalized during detailed engineering)
13. Time delay alarm - 5 to 500 ms, step 5 ms (for communication fail)
14. Time delay - 5 to 500 ms, step 5 ms (for switching to redundant channel)
15. Asymmetric delay - - 20 to +20 ms, step 1 ms (When echo mode is used)
16. Max. Transmission delay – 0 to 40 ms, step 1 ms

Distance Protection Relay

i) The distance protection relay shall be fully numerical using microprocessors and be based on a non-switched scheme.

ii) The distance protection relay shall have at least three completely independent non switched forward directional zones, one extended zone and a reverse directional zone protection.

iii) Have non-switched measurement, which implies processing of six possible fault loops (six –loop measurement).

iv) The protection algorithm shall utilize fault voltages and currents, as well as the superimposed voltages and currents to arrive at a secure trip decision in the shortest possible time with reliability, selectivity and full sensitivity to all types of faults online.

v) Have polygonal characteristics with independently adjustable reactive and resistive reaches for maximum selectivity and maximum fault resistance coverage. The zones shall have independent settable earth fault compensation factors to cater to adjacent lines with different zero sequence to positive sequence ratios.

vi) Selection shall be so that the first zone of the relay can be set to about 80% - 85% of the protected line without any risk of non-selective tripping.

ix) The second and third zone elements shall provide backup protection in the event of the carrier protection or the first zone element failing to clear the fault, zone-2 shall cover full protected section plus 50 % of the next section, zone-3 shall normally cover the two adjacent sections completely. The zones must have independent time settings.

x) Shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)

xi) All the zones shall have setting such that they can detect the fault online from minimum 0.3 km to 500 km.

xii) The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current. The starting and measuring relays characteristics should be satisfactory under these extreme varying conditions.

xiii) The relay shall use the memory voltage for proper directional discrimination at close in 3 phase fault which shall be based on positive sequence voltages. The directional discrimination and phase selection based on negative sequence measurement techniques is not acceptable.

xiv) Have adequate number of forward zones (minimum three) and a reverse zone. The zone reach setting ranges shall be sufficient to cover line lengths appropriate to each zone. Carrier aided scheme options such as permissive under reach, overreach, & blocking and non-carrier aided schemes of zone 1 extension and Loss of load accelerated tripping schemes shall be available as standard. Weak in feed logic and current reversal guard also shall be provided.

xv) In case the carrier channel fails, one out of the non-carrier-based schemes cited above should come into operation automatically to ensure high speed and simultaneous opening of breakers at both ends of the line.

xvi) Shall have suitable number of potential free contacts for Carrier Aided Tripping, Auto Reclosing, CB Failure, Disturbance/Fault recorder and Data Acquisition System.

xvii) Have a maximum operating time up to trip impulse to circuit breaker (complete protection time including applicable carrier and trip relay time) for SIR 0.01-4: as 40ms at the nearest end and 60ms at the other end of line & for SIR 4-15: as 45ms at the nearest end and 65ms at the other end of line with carrier transmission time taken as 20ms. Isochronic curves shall be provided in support of operating times.

xviii) Shall have an independent Directional Earth Fault (DEF) protection element to detect highly resistive faults as a built in feature. This element shall have an inverse time/definite time characteristic.

xix) Has logic to detect loss of single /two-phase voltage input as well as three-phase voltage loss during energisation and normal load conditions. The voltage circuit monitoring logic in addition to blocking the distance protection element, enable an emergency over current element to provide a standby protection to the feeder until the re-appearance of voltage signal.

xx) The VT fuse failure function shall function properly irrespective of the loading on the line. In other words, the function shall not be inhibited during operation of line under very low load conditions.

xxi) Have necessary logic to take care of switch-on-to-fault condition. Energisation of transformers at remote line ends and the accompanying inrush current shall not cause any instability to the operation of relay.

xxii) Have power swing blocking and Out of Step protection feature, with facilities for fast detection of power swing selective blocking of zones settable unblocking criteria for earth faults, phase faults and three phase faults. It shall be on the principle of measurement of the rate of impedance vector change and monitoring of the vector path. It should have the Earth fault detection feature, which shall override power swing blocking and allow the relay to operate for trip as per zone detection. The relay shall be blocked for the set time for the first PS sensed and remain unblocked for the set time for the successive PS.

xxiii) Be suitable for single pole or three pole tripping. However, relays offered for 132 kV lines provided with mechanically ganged circuit breakers, single pole tripping need not to be provided.

xxiv) Be suitable for both bus PT or Line PT/ CVT supply.

xxv) Shall have in built Trip circuit supervision facility to monitor both pre- and post close supervision facilities. An alarm shall be generated.

xxvi) Shall have in built broken conductor detection by way of level detector or negative sequence measurement.

xxvii) Shall have df/dt functions.

xxviii) Shall have multistage under frequency setting options.

xxix) The sensitivity of the logic shall not be affected during operation under low load.

xxx) Shall have a fault locator with an accuracy of ±3%. The display should be in kilometres and preferably in percentage impedance too. The fault locator should have built in mutual compensation for parallel circuit.

xxxi) Have mutual zero sequence compensation factor setting. The relay shall have facility to select different group settings to cater for mutual coupling on account of multi circuit line conditions. The minimum no. of group should be four.

xxxii Have at least 24 no of programmable BI and 32 no of programmable BO contact to cater for DR/SER carrier aided tripping auto re-closing etc.

xxxii) The distance relays shall have a built-in auto-reclose function with facilities for single pole / three pole / single and three pole tripping. It shall be possible to trigger the A/R function from an external protection**.** A voltage check function which can be programmed for deadline charging/dead bus charging / check synchronising shall be included. However, the relay shall support independent A/R scheme.

xxxiii) Shall have additional features to provide under/ over voltage protection.

xxxiv) Shall have additional features to provide under frequency protection

xxxv) Shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault.

xxxvi) The protective relays shall be suitable for use with capacitor voltage transformers having non electronic damping and transient response as per IEC.

xxxvii) Shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall be also capable of carrying a high short time current of 70 times rated current without damage for a period of 1 sec.

xxxviii) Must have a current reversal guard feature.

xxxix) Shall have Stub Protection function with current setting minimum range of 1 to 3 pu with definite time delay setting, minimum range of 0 to 100 msec

xl) Have feature of load encroachment blinder to safeguard the protection trip during heavy line loading condition.

Integrated Numerical Transformer Protection Relay

a) GENERAL REQUIREMENTS:

i) Shall be stable during magnetising inrush and over fluxing conditions. Stabilization under inrush conditions shall be based on the presence of second harmonic components in the differential currents.
ii) Shall have saturation discriminator as an additional safeguard for stability under through fault conditions.
iii) Shall have zero sequence current filtering, which may be deactivated separately for each winding, for special applications.
iv) Shall have software to take care of the angle & ratio correction of CT inputs.
v) Shall have all output relays suitable for both signals and trip duties

b) FUNCTIONAL DESCRIPTIONS:

The integrated Numerical Transformer Protection Scheme shall have following functional qualities:

1) Differential protection:

i) The relay shall be biased differential protection with triple slope tripping characteristics with faulty phase identification / indication. The range for the differential pick-up shall be from 0.1 to 2.5 p.u. Its operating time shall not exceed 30 ms at 5 times rated current.
ii) The relay shall have two adjustable bias slopes from 20 % to 150 % and slope from 40% to 150 %, to provide maximum sensitivity for internal faults with high stability for through faults
iii) The relay shall have an unrestrained high set element to back up the biased differential function and the setting range for it shall have a minimum setting of 5pu and a maximum setting of 30pu.
iv) The relay shall have the second harmonic restraint feature for stability under transformer inrush condition. The setting shall be 15-25%.
v) Further, the fifth harmonic blocking for stability under transient over fluxing condition shall be provided.
vi) Have suitable non-linear resistors along with stabilizing resistor for CT Circuit to limit peak voltage during in-zone faults in case of high impedance type.
vii) Have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre fault and post fault period: **Current in all three windings in nine analogue channels plus three analogue channels for Backup protection in case of 400kV class/ 220kV Class (In case of loaded tertiary) or 9 analogue channels for lower voltage transformers and voltage in three channel.**
viii) The Disturbance recorder function built in the Differential Protection IED shall have the facility to record the following external digital channel signals associated with transformer which shall be wired to differential relay apart from the digital signals pertaining to differential relay:
    a) REF Protection Operated
    b) HV Breaker Status (Main &Tie/Transfer both separately)
    c) IV/LV Breaker status (Main & Tie/Transfer both separately)
    d) Bucholz/OLTC/OTI/WTI alarm
    e) Bucholz/ PRD/ SPR Trip
    f) Group-A/ Group-B lockout relay trip

Necessary hardware and software, for automatic up loading of the data captured by disturbance recorder to the personal computer (DR Work Station) available in the sub station, shall be included in the scope.
ix) The Relay shall have Reverse Power Protection feature.
x) The Differential Relay shall be designed for the protection & control of 3 winding Transformer

2) Restricted Earth fault Protection:

The scheme shall have in-built restricted earth Fault (REF) for both the windings. The REF function shall be configurable to Auto Transformer also. This function should be provided to maximise the sensitivity of the protection of earth faults. **Both the Differential relay shall have inherent high impedence REF element**. The REF function should be able to share Current Transformers with the biased differential function. As in traditional REF protections, the function should respond only to the fundamental frequ ency component of the currents. For star/star transformer, both the windings shall be protected through REF, as such relay shall have sufficient analogue channels to accommodate the same.

3) Over fluxing Protection:

i) The over fluxing protection shall be built in the relay. By pairs of V/f and t, it shall be possible to plot the over fluxing characteristics so that accurate adaptation of the power transformer data is ensured.
ii) In addition, the relay should have a definite time element for alarm.
iii) The relay should monitor all the three phase voltages for calculation of V/f and should take the highest voltage for V/f calculation.

4) Thermal Overload Protection:

i) Shall have two stages of thermal overload protection for alarm and trip condition with continuously adjustable setting range of 100-400% of rated current and time constant setting range of 1.0 to 10.00sec continuously.
ii) Shall be single pole type.
iii) Shall have a drop off/pick up ratio greater than 95%.
iv) Shall have separately adjustable time delay relays for alarm having a setting range of 1to 10 seconds continuously.

5) Over Current and Earth fault protection:

i) The relay shall have three stages of definite time **Directional** over current protection as backup operating with separate measuring systems for the evaluation of the three phase currents, the negative sequence current and the residual current.
ii) In addition, the relay shall have three stages of Inverse time **Directional** over current protection operating based on one measuring system each for the three phase currents, the negative sequence current and the residual current.
iii) Shall have additional features to provide under/ over voltage protection.
iv) Shall have additional features to provide under frequency protection.
v) The Earth fault relay shall have directional IDMT characteristic with a definitive minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current. (with selectable IEC Curves).
vi) The Earth fault relay shall have low transient, overreach high set instantaneous unit of continuously variable setting range 200-800 % of rated current.

6) Transformer Neutral Current relay (for 400 KV class transformer only) shall

i) Have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current. (with selectable IEC Curves)

14.16.1 Over Current and Earth Fault Relays

These relays shall be of numeric, single/multi pole, directional /non-directional type with high set element as specified. These relays shall have the following features/characteristics:

(i) IDMT characteristic with definite minimum time of 3 second at 10 times setting.

(ii) Other operating curves such as inverse, very inverse shall be selectable

(iii) Adjustable setting range of 50-200 % and 20-80% of rated current for over current and earth fault relays respectively.

(iv) The directional relays shall have a Maximum torque angle of 45° current leading for directional over current unit & 30 lag for directional earth fault. Other MTAs should be settable

(v) Voltage polarizing coil: 63.5 or 110volt

(vi) Must have faulty phase, type of fault identification

(vii) The directional relays shall have over voltage/ under voltage & under frequency built in protection

(viii) The relay shall have blocking scheme on Reverse Power Flow.

(ix) Include LED indicators.

Reactor Protection

REACTOR DIFFERENTIAL PROTECTION RELAY Shall

(i). Be triple pole type.

(ii). Have operation time less than 25 milli-seconds at 5 times setting

(iii). Be tuned to system frequency.

(iv). Have an operating current sensitivity of at least 10% of nominal current

(v). Have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range

(vi). Be high impedance / biased differential type.

(vii). Have suitable non-linear resistors along with stabilizing resistor for CT Circuit to limit peak voltage during in-zone faults in case of high impedance type.

(viii). Be stable for all external faults.

REACTOR RESTRICTED EARTH FAULT PROTECTION RELAY shall

(i). Be single pole type.

(ii). Be of current/voltage operated high impedance type.

(iii). Have a current setting of 05-40% of 1 Amp. / have a suitable voltage setting range

(iv). Be tuned to system frequency

(v). Have a suitable non-linear resistor to limit the peak voltage to 1000 Volts.

REACTOR BACK UP IMPEDANCE PROTECTION RELAY shall

(i). Be triple pole type, with faulty phase identification/ indication.

(ii). Be single step polarized 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults

(iii). Have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable

(iv). Have an adjustable characteristic angle of 30-80 degree

(v). Have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds

(vi). Include VT failure relay which shall block the tripping during VT fuse failure condition.

(vii). Have Back Up over Current and Earth fault protection as built in function.

Circuit Breaker Protection

a) **LOCAL BREAKER BACK-UP PROTECTION SCHEME** shall

(i). Be triple pole type.

(ii). Have an operating time of less than 15 milli seconds

(iii). Have a resetting time of less than 15 milli seconds

(iv). Have three over current elements

(v). Be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer /reactor equipment protections

(vi). Have a setting range of 10-80% of rated current

(vii). Have a continuous thermal withstand two times rated current irrespective of the setting

(viii). Have a timer with continuously adjustable setting range of 0.1-1 seconds

(ix). Have necessary auxiliary relays to make a comprehensive Scheme

(x). Shall have re-trip feature for tripping its own CB after initiation with a set time delay.

(xi). Be acceptable as Built-in protection function of distributed bus bar protection scheme only; however in that case separate LBB relay shall be provided for tie bays.

b) **NUMERICAL AUTO RECLOSING FUNCTION** (where specified) shall be an in built feature of Main-I and Main-II protection relay. The Auto Reclose shall

(i). Have single phase and three phase reclosing facilities.

(ii). Have a continuously variable single-phase dead time range of 0.1-2 Seconds

(iii). Have a continuously variable three phase dead time range of 0.1-2 Seconds

(iv). Have a continuously variable reclaim time range of 5-300 seconds

(v). Incorporate a four-position selector switch/ from which single phase/three phase/single and three phase auto-reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through HMI of the relay or BCU & SAS.

(vi). Have facilities for selecting check synchronizing or dead line charging features. It shall be possible at any time to change the required feature by reconnection of links.

(vii). Be of single shot type

(viii). Have priority circuit to closing of both circuit breakers in case one and half breaker arrangements to allow sequential closing of breakers

(ix). Include check synchronizing relay which shall

- Have a time setting continuously variable between 0.5-5 seconds with a facility of additional 10 seconds
- Have a response time within 200 milli seconds with the timer disconnected.
- Have a phase angle setting not exceeding 35 degree
- Have a voltage difference setting not exceeding 10%
- Include deadline charging relay, which shall
- Have two sets of relays and each set shall be able to monitor the three-phase voltage where one set shall be connected to the line CVTs with a fixed setting of 20% of rated voltage and the other set shall be connected to the bus CVTs with a fixed setting of 80% of rated voltage.
- Incorporate necessary auxiliary relays and timers to give comprehensive scheme.

Auto Reclose function shall be an in-built feature of the BCU and the signal exchange for auto-reclose function from BCU to main relays and vice versa shall be achieved through hard wiring and GOOSE parallelly.

14.14 Bus Bar Protection Relay

a) These relays shall also be of numeric type.

b) Redundant (1+1) numerical low impedance biased differential Bus Bar protection scheme for each bus system (Bus1 +Bus2) for 400kV shall be provided. The scheme shall be engineered so as to ensure that operation of any one out of two schemes connected to main faulty bus shall result in tripping of the same.

c)Single bus bar protection scheme shall be provided for each main bus **(Main I/Main II)** and transfer bus (as applicable) for 220KV and **132kV** voltage level.

d) Each Bus Bar protection scheme shall

i) Have maximum operating time up to trip impulse to trip relay for all types of faults of 25 milli seconds at 5 times setting value.

ii) Operate selectively for each bus bar

iii) Give hundred percent security up to 63 KA for fault level for 400 KV , 50kA for 220 KV and 40 KA for 132 KV

iv) Incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm

v) Not give false operation during normal load flow in bus bars

vi) Incorporate clear zone indication

e) It shall have End fault Protection & LBB function

f). Be of phase segregated and triple pole type. The bus bar scheme may be Centralized or De-Centralized type and it must accommodate all future bays as per Project along with tripping relays.

g) Provide independent zones of protection (including transfer bus if any). If the bus section is provided, then each side of bus section shall have separate set of bus bar protection schemes

h) Include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.

i) Be transient free in operation

j) Include continuous D.C. supplies supervision

a) Not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.

b) Shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm

c)Include protection 'IN/OUT' switch for each zone

d) Shall include trip relays, CT switching relays (if applicable) , auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However, for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers covered under this specification. Suitable panels (if required) to mount these are also included in the scope of the work.

e) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard panel room where bus bar protection panel shall be installed.

Tee Differential Protection Relays (If Applicable)

1) **TEE-1 DIFFERENTIAL (BIAS) PROTECTION RELAY** shall
   (a) be triple pole type
   (b) have an operating time less than 30 milliseconds at 5 times the rated current
   (c) have three instantaneous high set over current units
   (d) have an adjustable bias setting range of 20-50%
   (e) have an operating current setting of 15% of 1 Amp or less

2) **TEE-2 DIFFERENTIAL (HIGH IMPEDANCE) PROTECTION RELAY** shall
   (a) be triple pole type
   (b) have operating time less than 25 milliseconds at 5 times setting
   (c) be tuned to system frequency
   (d) have current setting range of 20 to 80% of 1 Amp
   (e) be voltage operated, high impedance type
   (f) be stable for all external faults
   (g) be provided with suitable nonlinear resistors across the relay to limit the peak voltage to 1000 volts

Trip Circuit Supervision Relay

- Trip circuit supervision relay shall be provided for each pole of the breaker for both trip coils with separate DC source.
- The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.
- The relay shall have adequate contacts for providing connection to alarm and event logger.
- The relay shall have time delay on drop-off of not less than 200 milli seconds and be provided with operation indications for each phase.

Master Trip Relay

- High Speed Tripping Relay shall be instantaneous (operating time not to exceed 10 milli-seconds
- The relays shall reset within 20 milli seconds
- The relay shall be re-settable/configurable from local SCADA.
- The relays shall be D.C. operated
- The relays shall have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger, Disturbance recorder, fault Locator, etc.
- The relays shall be provided with operation indicators for each element/coil.

Other Trip Relays

- For transformer protection other trip relays for Buchholz, winding & oil temperature high, PRD etc. shall be provided as per requirement.

- These High-Speed Tripping Relays shall be instantaneous (operating time not to exceed 10 milli-seconds)
- The relays shall have adequate contacts to meet the requirement of scheme

DC Supply Supervision Relay

- The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.
- It shall have adequate potential free contacts to meet the scheme requirement.
- The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and the relays shall be provided with operation indicator/flag.

TIME SYNCHRONISATION EQUIPMENT:

- The equipment must be Type tested for Shock, Vibration, Dry heat, Radiated Emission, Electromagnetic field immunity, Electrostatic discharge immunity test in a Standard Laboratory. Type test report shall be submitted along with the bid. Type tests shall be more than five years as on opening of this bid.
- The equipment shall be compliant to IEC 61850 Protocol. It shall also support the network protocols like NTPv4, SNTP, SNMPv1,2,3, SNMP Trap, SSH2, Ipv6, DHCP, HTTP (S), eMail, FTP, TELNET and Syslog
- The Time synchronisation equipment shall receive the coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronise equipment to the Indian Standard Time in a substation.
- Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.
- It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.
- Equipment shall operate up to the ambient temperature of 50 degree centigrade and 100% humidity.
- The synchronisation equipment shall have 20 nano second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc.) including communication time for satellite link to achieve real time signal.
- Equipment shall meet the requirement of IEC 60255 for storage & operation.

- The system shall be able to track the satellites to ensure no interruption of synchronisation signal.
- The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.
- The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following:

    1) Voltage signal: Normally 0-5V with 50 milli Seconds minimum pulse duration. In case any other voltage signal required, it shall be decided during detailed engineering.
    2) Potential free contact (Minimum pulse duration of 50 milli Seconds.)
    3) IRIG-B
    4) RS232C
    5) RJ 45
    6) SNTP
    7) Optical
    8) IEEE 1588 PTP (Applicable only for process bus automation station)
- The equipment shall have a periodic time correction facility of one-second periodicity.
- Time synchronisation equipment shall be suitable to operate from 80V-250V DC supply available at the sub-station with voltage variation of + 10% and -15%.
- . Equipment shall have real time digital display in hour, minute, second (24-hour mode) & have a separate time display unit to be mounted on the top of control panels/SAS Panels having display size of approx. 100 mm height.
- The cable connecting Antenna and Time Synchronising unit should be run through HDPE pipe or GI pipe from the location of Antenna fixing to Time Synchronising panel with suitable fixtures and no provision to enter rainwater and should not be affected by atmospheric conditions.
- Time Synchronisation software shall be window base and it should be provided free of cost after commissioning**.**

BAY CONTROL UNIT (BCU)

- The BCU must be type tested at KEMA/Internationally or nationally acreditted other testing laboratories for IEC 61850 and other tests as per relevant IEC standards. The bidder is to submit type test reports along with the bid. The validity of type test report shall be as per Clause 14.4.2(iii).

- The bay unit shall use industrial grade components. The BCU shall be modular type. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. These shall incorporate select- before-operate control principles as safety measures for operation via the HMI. These shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. These shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, these shall receive the operation commands from station HMI and SLDC. The bay unit shall have the capability to store all the data for at least 24 hours even if there is any power off conditions during the day. **The BCU shall have Auto Reclose, LBB, U/O voltage and Synchronization function. The BCU shall have redundant power supply card i.e. in case of failure of one source/Card fail, the redundant shall pick up instantly. Power supply card failure shall generate necessary alarm to local SCADA.**

- The BCU must have metering functions like phase current, phase voltages, active & apparent power, power factor, frequency etc. The metering functions shall be accurate for a minimum of 1% of rated current.

- BCU HMI shall display complete mimic of the respective bay, and operator shall be able to select the equipment in the mimic diagram for which operation of equipment is required. The control operation shall be password protected. For 33kV, the HMI should display one bay and control thereof.

- The mimic diagram shall indicate the live & dead portion of the Bay.
- The BCU shall be capable to generate password for maintenance shutdown.
- One Bay level unit shall be provided for supervision and control of each 400KV, 220KV, 132kV and 33kV bay (a bay comprises of one circuit breaker and associated disconnectors, earth switches and instrument transformer). If the 33kV bus section comprises isolator only, then the isolator shall be controlled from the transformer LV side bay and same is the case for Bus PT Isolator which shall be controlled by Transformer LV side BCU. The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.
- The BCU shall have sufficient number of BI/BO as per the scheme requirement with additional 30% spare BI/BO.
- The Bay level units shall be installed in the control and relay panels located in the control room.
- The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.
- **Input / Output (I/O) modules**

  The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear.

  The measured values of SF6 Gas Pressures, Operating Mechanism Pressures, WTIs, OTI etc. are received through transducers to Bay Level Unit

  The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state.
- **Operator Interface**

  The HMI of BCU shall display the following informations
  i) the bay name
  ii) the date and time
  iii) the Local / Remote/Maintenance bay mode
  iv) the auto-recloser function status (on / off),
  v) the synchrocheck function status (on / off),
  vi) the interlock function status (on / off),
  vii) a list of measurements (in real value)

viii) the bay graphical representation
ix) the bay events classified in a chronological order
x) the bay alarms
xi) the list of disturbance records available
xii) Bay interlock diagram

In addition, it shall be possible to plug a PC laptop on the Bay and get the full substation operator interface.

SWITCHED ETHERNET COMMUNICATION INFRASTRUCTURE:

The bidder shall provide the redundant managed switched optical Ethernet communication infrastructure for SAS against PRP architecture. The necessary switches are provided for communication infrastructure as follows.

14.25.1 One switch shall be provided to connect all IEDs for 1 Bay in LAN –I and the second optical port of Bay IEDs shall be connected to other Ethernet Switch in LAN-2. The maximum number of bays may be connected to these Ethernet Switch shall be two bays for 400KV, 220kV and 132kV. However, for 33kV, 3 numbers bay may be connected to one Ethernet Switch in this PRP architecture. The exact no of Ethernet switches required for complete implementation of the scheme shall decided during detailed engineering.

14.25.2 The managed Ethernet switch shall have minimum 20% port redundancy (Both Fibre & Copper ports).

14.25.3 Ethernet Switches shall have redundant power card.

14.25.4 Port monitoring softwares for Ethernet Switches are to be provided.

14.25.5 The make of the Ethernet switches shall be Ruggedcom/Hirschman/ABB.

FAULT RECORDER:

14.14.1 The fault recorder shall be provided for transmission line and the fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.

14.14.2 Fault recorder shall be capable to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances.

14.14.3 The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit (as described in section sub-station automation through bus conforming to IEC 61850) which is common for the entire Substation. Necessary hardware and software shall also be supplied for online transfer of data from all acquisition units to Evaluation unit.

14.14.4 Fault recorder shall have at least 8 analogue and 16 digital channels for each feeder.

14.14.5 Acquisition units shall acquire the Disturbance data for the pre fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.

14.14.6 The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.

14.14.7 The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which are prone to various interference signals typically from large switching transients.

14.14.8 The evaluation unit hardware shall be as described in clause no. 4.0 of section sub-station automation.

14.14.9 Necessary software for transferring the data automatically from local evaluation unit to a remote station and receiving the same at the remote station through owner's PLCC/VSAT/LEASED LINE shall be provided.

14.14.10 Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analogue and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analogue channel, group of

signal to be drawn on the same axis etc, listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and voltage wave forms. The Disturbance records shall also be available in COMTRADE format (IEEE standard- Common Format for Transient data Exchange for Power System)

14.14.11 The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.

14.14.12 Fault recorder acquisition units shall be suitable to operate from 220V DC as available at sub-station Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Distance recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in section sub-station automation clause no. 8.0 and DR evaluation unit.

14.14.13 The acquisition unit shall have the following features:

i) Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc. and same shall be wired to annunciation system.

ii) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.

iii) Scan rate shall be 1000 Hz/channel or better.

iv) Pre-fault time shall not be less than 100 milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system fault occurs during one post-fault run time, the recorder shall also be able to record the same. However, the total memory of acquisition unit shall not be less than 5.0 seconds.

v) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.

vi) The acquisition unit shall be typically used to record the following digital channels:

1. Main CB R phase open
2. Main CB Y phase open
3. Main CB B phase open
4. Main-1 carrier received
5. Main-1 protection operated
6. Main/Tie /TBC Auto reclosed operated
7. Over Voltage -Stage-1 /2 operated
8. Reactor / Stub/TEE-1/2/UF protection operated
9. Direct Trip received
10. Main-2 carrier received
11. Main- 2/ Back Up protection operated
12. Bus bar protections operated
13. LBB operated of main /tie/TBC circuit breaker
14. Tie/TBC CB R phase open
15. Tie/TBC CB Y phase open
16. Tie/TBC CB B phase open

vii) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.

viii) Any digital signal can be programmed to act as trigger for the acquisition unit. Analogue channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.

14.14.14 The printer shall be compatible with the desktop PC and shall use Plain paper. The printout shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analogue and digital signals of all the channels. Two packets of paper (500 sheets in each packet) suitable for printer shall be supplied.

14.14.15 Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to +0.5 seconds/day, if allowed to run without synchronization. Further, Fault recorder shall have facility to synchronize its time generator from Time Synchronization Equipment having output of following types.

i) Voltage signal: (0-5V continuously settable, with 50m Sec. minimum pulse duration).

ii) Potential free contact (Minimum pulse duration of 50 m Sec.)

iii) IRIG-B/SNTP

iv) RS232C/RS485/RJ 45/Optical port.

The recorder shall give annunciation in case of absence of synchronizing within a specified time.

DISTANCE TO FAULT LOCATOR:

14.14.16 The Distance to Fault Locator shall be provided for transmission line and the fault locator as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.

14.14.17 Distance to Fault Locator shall be electronic or microprocessor based and 'Online' type with built-in display unit.

14.14.18 The display shall be directly in percent of line length or kilometers without requiring any further calculations.

14.14.19 It shall have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays. The accuracy should not be impaired under the following conditions:

i) presence of remote end in-feed

ii) predominant D.C. component in fault current

iii) high fault arc resistance

iv) severe CVT transients

14.14.20 It shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line.

PROTECTION SCHEME FOR PANELS:

- **400KV Line Panel**

The following protections scheme shall be provided for Panels for 400 KV Transmission lines:

Main Protection Scheme I & II:

Distance protection scheme using Numerical Relay as specified in detail in Clause 14.15 and 14.16.2 shall be implemented. The summary of the scheme detailed in the above clauses have the following feature:

(i) Permissive under reach/over reach/ blocking communication mode.

(ii) Suitable for single cum three phase tripping.

(iii) Power swing blocking and out of step protection.

(iv) Single shot single-cum-three phase auto re-closing with check synchronising and deadline charging features.

(v) Fuse failure protection.

(vi) Weak end in feed feature.

(vii) Over/Under Voltage Protection

(viii) Directional Over current and Earth Fault protection

(ix) Current reversal guard feature

(x) Stub protection function

(xi) Load encroachment blinder feature.

(xii) Switch on to fault feature.

(xiii) In built Broken Conductor detection feature.

(xiv) Shall have df/dt functions

(xv) Under frequency protection

(xvi) Carrier Aided Tripping

(xvii) Main 1 and Main 2 relay shall of different make **and model**.

- **220 KV Line Panel**

The following protections scheme shall be provided for Panels for 220 KV Transmission lines:

a) Main Protection Scheme I & II:

Distance protection scheme using Numerical Relay as specified in detail in Clause 14.15 and 14.16.2 shall be implemented. The summary of the scheme detailed in the above clauses have the following feature:

(i) Permissive under reach/over reach/ blocking communication mode.

(ii) Suitable for single cum three phase tripping.

(iii) Power swing blocking and out of step protection.

(iv) Single shot single-cum-three phase auto re-closing with check synchronising and deadline charging features.

(v) Fuse failure protection.

(vi) Weak end in feed feature.

(vii) Over/Under Voltage Protection

(viii) Directional Over current and Earth Fault protection

(ix) Current reversal guard feature

(x) Stub protection function

(xi) Load encroachment blinder feature.

(xii) Switch on to fault feature.

(xiii) In built Broken Conductor detection feature.

(xiv) Shall have df/dt functions

(xv) Under frequency protection

(xvi) Main 1 and Main 2 relay shall of different **make and model**.

- **132 KV Line Panel**
  The following protections scheme shall be provided for Panels for 132 kV Transmission lines:

  a) Main Protection Scheme I:

  Distance protection scheme using Numerical Relay as specified in Clause 14.15 and 14.16.2.

  b) Backup Protection:

  The backup protection shall be provided with directional single/ multi pole relays as specified in Clause 14.16.4. One triple pole over current relays for phase faults and one Earth Fault Relay for Earth Faults without high set elements shall be provided.

- **33KV Feeder Protection Panel**

  The 33kV Feeder Panels shall be provided non directional single/ multi pole relays as specified in Clause 14.16.4. One triple pole over current relays for phase faults and one Earth Fault Relay for Earth Faults with high set elements shall be provided.

- **Power and Auto Transformer Protection Panel**
  Integrated Transformer protection scheme as detailed in Clause 14.16.3 of the BID shall be provided for Panels for all Power and Auto Transformers:

  (a) Main Protection -1

  Biased transformer differential protection employing relay type specified in Clause 14.32. The scheme shall include also following:
  (i) Second and fifth harmonic restraint feature.
  (ii) The relay shall also provide Restricted Earth Fault Protection
  (iii) The scheme shall have suitable input and output for transformer auxiliary protection like Buchholz, oil temperature, winding temperature etc.
  (iv) Over-fluxing protection
  (v) The relay shall have Back up protection features i.e Directional over current and earth fault with high set element. The high set unit should not operate due to transformer in-rush current.

(b) Main Protection - 2

Protection function shall be same as Main Protection – I.

(c) Backup Protection: The backup protection shall be provided with Directional relays as specified in Clause 14.16.3. One triple pole over current relays for phase faults and one E arth Fault Relay for Earth Faults with high set elements shall be provided. The high set unit should not operate due t o transformer in-rush current.

- **Bus Bar Differential Protection Panel:**
- The Bus Bar Protection shall be provided as detailed in Clause 14.17 of the BID for 400kV, 220kV and 132kV Voltage Level.

- **Reactor Protection Panel:**
  The Reactor Protection shall be provided as detailed in Clause 14.16.5 of the BID.

RELAY MAINTENANCE TOOL KIT

MAINTENANCE TOOL KIT

- The bidder shall supply a complete maintenance tool kit set. The tool kit shall have generally current jack, card extender, card puller, required crimping tool, screw drivers, pliers etc.
- The tool kit shall contain test plugs, test leads, clips for maintenance and testing of relays supplied. Further detailing will be done during detail engineering.
- The Maintenance Tool Kit shall be of Universal type.

14.15 TESTS

- The supplier shall carryout all tests as per relevant standards as all associated equipment including relays, meters, instruments etc. The supplier shall submit all that reports to Employer for approval before despatching the control and relay panels. The Bidder shall also submit along with the bid type test reports for relays instruments, meters and other devices of the type and class being offered. Bidder has to submit KEMA test certificate for Numeric relay on interoperability compliance of IEC 61850 in general and GOOSE messaging and publishing in particular along with the bid.
- Control and relay panels shall be subjected to the following tests:

  a. Mechanical operation test.
  b. Verification of degree of protection.
  c. High voltage test (2000 volts for 1 minute)
  d. Electrical control interlock and sequential operation test.
  e. Verification of wiring as per approved schematic.
  f. Interoperability test as per IEC 61850 (interoperability with ABB, AREVA, SIEMENS, GE and SEL)

14.16 PRE-COMMISSIONING TESTS

- The contractor shall have to perform following minimum Pre-commissioning tests for commissioning of the C&R panels. For this purpose, the contractor shall arrange all required tools and testing equipment at site

  (i). IR values of all circuits
  (ii). Measurement of burden in CT & PT circuits
  (iii). Primary current injection of CT circuits with connected burden
  (iv). Energisation of PTs at suitable low voltage and measurement of PT inputs at all measuring points
  (v). Secondary ac current injection of relays, dynamic testing of all numeric relays. Tracing of zone curves, limits. Checking of relay timings, inherent or set values. For this testing, the contractor shall bring 'Omicron' or equivalent test kit.

(vi). Testing of voltage related elements like directional element, over fluxing, over/ under frequency, over/ under voltage features, tracing of curves and checking limits of set values and associated timings

(vii). Checking of Boolean logic gates, BI/BO points of the numeric relays, checking conformity to specification and checking of set logics

(viii). Checking of stability and sensitivity of differential zones by suitably applying 3-phase low voltages and shorting of primary circuits. Measurements of voltage and current inputs to all relays.

(ix). Checking stability & sensitivity of bus differential relay zones by suitably injecting current

(x). Primary injection of REF connected CTs, measurements of relay inputs and checking of stability and sensitivity of REF scheme

(xi). Checking registration of event and disturbance records in the numeric relays and downloading

(xii). Testing of carrier aided protection schemes and simulation with regard to transmission and receipt of protection signalling

(xiii). Testing of AR schemes

(xiv). Checking of healthiness of each dc circuit of panels

(xv). Simulation of faults like Buchholz, OTI, WTI and other relays and checking of tripping of breaker and connected annunciation

(xvi). Operation of master trip relays, tripping of breaker through each trip coil and checking of interlocks

(xvii). Simulation of faults like low gas, air pressure and checking operation of interlocks. Checking anti pumping scheme of CB

(xviii). Simulation to Check Checking of PT selection schemes

(xix). Simulation to Check interlocks of all CB and isolator interlocks

(xx). Simulation to Check annunciation of all events in BCU (Bay control unit) as well as SAS (Sub-station Automation System)

(xxi). Simulation to Check of logic of BCU

(xxii). Operation of tap changing of transformer through SAS

(xxiii) The pre-commissioning checklist will be further developed by the contractor and will seek approval prior to commencement of pre-commissioning tests from the DGM, MRT Circle, AEGCL. The tests will be witnessed and approved by him or by his authorized officers.

TECHNICAL DATA SHEET FOR THE RELAY AND CONTROL PANELS

- Features to be provided in various Relay and Control panels are indicated below. Description below are only indicative; the Contractor shall ensure that all items are included in their offer to complete the schemes described in the Specification whether such items are specifically mentioned or not.

400kV and 220kV Feeder Panels:

SL NO	ITEM	RATINGS AND PARTICULARS	
		400KV Panel with 1 1/2 Breaker Scheme	220KV Panel with Main I & Main II
I	II	III	IV
A	**LINE PANELS**		
1	**Protection and relays:**		
	(a) Distance Protection Scheme I	1 No.	1 No.
	(b) Distance Protection Scheme II	1 no	1 no
	(c) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(d) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 6 trip coils (2 trip coils per pole or phase)	Supervision for 6 trip coils (2 trip coils per pole or phase)
	(e) DC Supply healthy monitoring scheme for two separate DC source	2 No.	2 No.

	(e 1)DC Changeover Relay	2 Nos	2 Nos
	(f) AC Supply healthy monitoring scheme	1 No.	1 No.
	(g) High Speed Trip relay (1 & 3 pole)	2 sets.(each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)	2 sets.(each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)
	(h)PT-CVTSelectionSchemewithPT1-PT2-CVTselectionrelay	1 Set. Complete Bus PT1-Bus PT2-CVT Selection Scheme	1 Set. Complete Bus PT1-Bus PT2-CVT Selection Scheme
	(i) Auxiliary relay, timer relay for healthiness of relays, auto reclose communication link etc.	As required (Can be function of BCU)	As required (Can be function of BCU)
	(j) Trip Transfer Relay	-	2 sets
	(j) Fault Recorder	1 set (shall be function of IED)	1 set (shall be function of IED)
	(k) Distance to fault locator	1 set (shall be function of IED)	1 set (shall be function of IED)
	(l) Under Voltage protection relay for isolator/earth switch Interlock	2 nos	2 nos
	(m) Over Voltage Protection Scheme	1 set (maybe function of IED)	1 Set (maybe function of IED)
2	**Meters**		
	(a) ABT tri-vector Meter (SAMAST Compliant) with TTB	1No	1No
3	**Controls/ Status indication/ Annunciation**		
	Bay control unit (IED)	1No. (Function of BCU/ SAS)	1No. (Function of BCU/ SAS)

132kV and 33kV feeder Panels:

SL NO	ITEM	RATINGS AND PARTICULARS	
		132 kV Panel with Main & Transfer Bus Scheme	33 kV feeder panel with single bus system
		V	VI
A	**LINE PANELS**		
1	**Protection and relays:**		
	(a) Distance Protection Scheme	1 No.	-.
	(b) Back up directional over current and earth fault scheme	1 Set	-
	(c) Back up non directional over current and earth fault scheme	-	1 set
	(d) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs

	(e) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 2 trip coils	Supervision for 2 trip coils
	(f) DC Supply healthy monitoring scheme, for two DC source	2 No.	2 No.
	(f 1) DC Changeover	2 Nos	2 Nos
	(g) AC Supply healthy monitoring Scheme	1 No.	1 No.
	(h) High Speed Trip relay	2 No.	2 No.
	(h1) High Speed Trip Relay for LBB	1 No	1 No
	(i) Auxiliary relay, timer relay for healthiness of relays, auto reclose communication link etc.	As required (Can be function of BCU)	As required (Can be function of BCU)
	(j) Trip Transfer Relay	2 sets	2 sets
	(j) Line CVT-Bus PT selection relay	1 No	-
	(k) 33kV Incomer PT selection	-	-
	(l) Distance to Fault Locator	1 set (shall be function of IED)	-
	(m) Fault Recorder	1 set (shall be function of IED)	
	(l) Under Voltage protection relay for isolator/earth switch Interlock	2 nos **(function of IED)**	
	(m) Over Voltage Protection Scheme	1 set (maybe function of IED)	
2	**Meters**		
	(a) ABT tri-vector Meter (SAMAST Compliant) with TTB	1 No	1 No
3	**Controls/ Status indication/ Annunciation**		
	Bay Control Unit (IED with HMI)	1No. (Function of BCU/ SAS)	1No.

Transformer Protection Panels

SL NO	ITEM	RATINGS AND PARTICULARS			
		400/220/33 kV Transformer Panel	220/132 kV Transformer Panel	220/33 kV Transformer Panel	132/33kV Transformer Panel
		VII	VIII	IX	X
B	**TRANSFORMER PANELS**				
1	**Protection and Relays:**				
	(a) Differential Protection Scheme	2 No.	2 No.	2 No.	2 No.
	(b) Restricted Earth Fault Protection Scheme	(inherent High imp REF)	(inherent High imp REF)	(inherent High imp REF)	(inherent High imp REF)

	(c) Back up directional over current scheme and earth fault scheme for HV side.	Could be feature of relay	Could be feature of relay	Could be feature of relay	Could be feature of relay
	(d) Back up directional over current and earth fault scheme for MV/LV Side.	Could be feature of relay	Could be feature of relay	Could be feature of relay	Could be feature of relay
	(e) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(f) Over Fluxing Protection scheme	Can be function of IED	Can be function of IED	Can be function of IED	Can be function of IED
	(g) Overload protection scheme	Can be function of IED	Can be function of IED	Can be function of IED	Can be function of IED
	(g.1) Tertiary Side O/C and Open Delta Voltage Protection	1 set	1 set	-	-
	(h) Trip Circuit Supervision Relay Scheme for ascertaining pre and post-closing healthiness.	Supervision for 4/12 trip coils(2trip coilsper pole/ breaker on each side)	Supervisi onfor 4/8 trip coils(2 tripcoils per pole/ breaker on each side)	Supervisi onfor 4/8 trip coils(2 tripcoils per pole/brea ker on each side)	Supervision for 4 trip coils(2 tripcoils per breaker on each side)
	(i) DC Supply healthy monitoring scheme	**2 No.**	**2 No..**	2 No.	2 No.
	(i1) DC Changeover Relay	2 No.	2 No.	2 No.	2 No.
	(j) AC Supply healthy monitoring scheme	1 No.	1 No.	1 No.	1 No.
	(k) High Speed Trip relay (HV Side)	2 No.	2 No.	2 No.	2 No.
	(l) High Speed Trip relay (MV/LV Side)	2 No.	2 No.	2 No.	2 No.
	(m) Trip Transfer Relay	2 sets	2 sets	2 sets	2 sets
	(m) PT Selection Scheme on HV / MV/LV Side as applicable	1No. Complete Bus PT Selection Scheme (Can befunctionof BCU)	1No. Complete Bus PT Selection Scheme (Canbe functionof BCU)	1No. Complete Bus PTselection scheme (can be function of BCU)	1No. Complete Bus PTselection scheme (can be function of BCU)
	(m1) PT Selection Relay	3 Nos for HV/ 2 Nos for LV	2 Nos for HV/ 2 No for MV	2 Nos for HV/ 2 No for LV	1 No for HV/ 2 No for LV
	(n) Tripping relay for Bucholtz, PRD, WTI, OTI , OSR etc.	As required	As required	As required	As required
	(o) Alarm auxiliary for Bucholtz, PRD, WTI, OTI, MOG , Air Cell leakage etc.	As required (Can be a function of BCU)	As required (Can be a function of BCU)	As required (Can be a function of BCU)	As required(Can be a function of BCU)
	(p) Transformer tap position status/ raise & lower	Can be a function of BCU	Can be a function of BCU	Can be a function of BCU	Can be a function of BCU
	(q) Reverse Power Protection	Can be function of IED	Can be function of IED	Can be function of IED	Can be function of IED
2	**Meters**				
	(a) ABT tri-vector Meter (SAMAST Compliant) With TTB	2 No. (on 400kV and 220 kV side)	2No. (on 220 kV and 132 kV side)	2No. (on 220 kV and 33kV side)	2 Nos. (132 kV & 33 kV side)

3	**Controls / interlocks / Status indication/ Annunciation**				
	Bay Control Unit (IED), one no each for HV & LV side.	2 Nos. (Function of BCU/ SAS)	2 Nos. (Function of BCU/ SAS)	2 Nos. (Function of BCU/ SAS)	2 Nos. (Function of BCU/ SAS)

Reactor Protection Panel

The Reactor Protection Panel shall consist of following protection features/schemes:

SL. NO	**Description**	**400 kV**
		XI
1	Reactor Differential Protection scheme	1 No
2	Restricted Earth fault Protection scheme:	1 No
3	Reactor back up impedance protection scheme	1 Set
4	Three phase trip relays (Only for Bus Reactor)	2 Nos.
5	CVT selection relay as per scheme requirement	Lot

400kV, 220 kV and 132 kV Bus Coupler / Bypass Breaker Panel

SL NO	ITEM	RATINGS AND PARTICULARS	
		220 kV Panel with Main I & Main II Scheme	132 kV Panel with Main 1 & Transfer Bus Scheme
		XII	**XIII**
A	**BUS COUPLER PANEL**		
1	**Protection and relays:**		
	(a) Back up directional over current and earth fault scheme	1 Set	1 Set
	(b) Bus Bar differential protection	Main I and Main II	Applicable, where specified in BoQ
	(c) LBB Protection Scheme.	Can be function of BCU/IEDs	Can be function of BCU/IEDs
	(d) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 6 trip coils (2 trip coil for each Phase)	Supervision for 2 trip coils
	(e) DC Supply healthy monitoring scheme	2 No.	2 No.

	(e)DC Changeover Relay	2 No.	2 No.
	(f)ACSupplyhealthymonitoringscheme	1 No.	1 No.
	(g) High Speed Trip relay	2 Sets. .(each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)	2 No.
	(h) PT Selection Scheme	1No. Complete Bus PT Selection Scheme (Can be function of BCU)	Not applicable
	(i) Auxiliary relay, timer relay scheme	As required	As required
2	**Metering**	Function of BCU/ SAS	Function of BCU/ SAS
3	Controls/Annunciation/Statusindication		
	Bay control unit (IED)	1 No. (Function of BCU/ SAS)	1 No. (Function of BCU/ SAS)

400kV Tie Breaker Panel

SL NO	ITEM	Ratings and Particulars
		4000 kV Panel with 1 1/2 Breaker Scheme
		XIV
B	**TIE PANEL**	
1	**Protection and relays:**	
	(a) Back up directional over current and earth fault scheme	
	(b) Bus Bar differential protection	
	(c) LBB Relay.	1 No
	(d) Trip Circuit Supervision Relay for pre and post-closing	Supervision for 6 trip coils (2 trip coils per pole or phase)
	(e)DC Supply healthymonitoring scheme	2 No.
	(f) DC Changeover Relay	2 No
	(f)ACSupplyhealthymonitoringscheme	1 No.
	(g) High Speed Trip relay	2Sets. (each set will comprise of 3 Nos of 1ph trip relay and 1 No of 3ph trip relay)
	(h) Auxiliary relay, timer relay scheme	As required
2	**Metering**	Function of BCU/ SAS
3	Controls/Annunciation/Status indication	
	Bay control unit (IED)	1 No.

14.17 Monitoring, Control & Protection for Auxiliary Transformer

Suitable monitoring, control (operation of associated Circuit breaker and isolator) and protection for LT Auxiliary Transformer, connected to tertiary winding of auto transformer for the purpose of auxiliary supply shall be provided by the contractor. Overcurrent and open delta protection is required to be provided for the auxiliary transformer. These control and protection shall also be acceptable as built in feature either in the bay controller to be provided for the auxiliary system or in the control and protection IEDs to be provided for the auto transformer.

NOTE: 1) The relays (main / auxiliary) not covered within the above table shall be considered for complete commissioning of the protection scheme.

2) In Case of incomplete Diameter (D and I type layouts), control panel shall be equipped fully as if the Diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.

3) Relay setting template (in editable document format) shall be provided by the Contractor for each typical protection IEDs for relay setting purpose.

4) For GIS Sub Stations, GIS Gas Zone trip signals, if provided, for each gas tight compartments (gas zone) in the GIS LCC shall be integrated in the protection schematics to provide electrical isolation of faulty Gas Zone by tripping/ inter tripping its adjacent circuit breakers. The scheme shall be implemented through protection IEDs and auxiliary relay as required.

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 accredited certificate for all IEDs and Ethernet switches conforming to IEC 61850 is to be furnished as qualification requirement.

SAS integration shall be in the scope of the bidder along with integration with the existing busbar scheme. All the accessories required for successful SAS integration and integration with the busbar scheme (as per site requirement) shall be under the scope of Bidder.

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 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 Free Fall Packaging Test	IEC 60068-2-31 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 : 1g from 2 to 150Hz
		Classe 2 : Acceleration : 1g from 10 (1) to 150Hz
Vibration Response – Not Powered On	IEC 60255-21-1	Class 2 : 2g from 2 to 500Hz
		Classe 2 : Acceleration : 2g from 10 (1) to 500Hz
Vibration Endurance – Not Powered On	IEC 80068-2-6	Class 2 : 1g from 10 to 150Hz
		Class 2 : Acceleration : 1g from 10 (1) to 500Hz
Shocks – Not Powered On	IEC 60255-21-2	Class 1 : 15g, 11 ms
Shocks – Powered On	IEC 60255-21-2	Class 2 : 10g, 11 ms
Bump Test – Not Powered On	IEC 60255-21-2	Class 1 : 10g, 16ms, 2000/axis
Seismic Test – Powered On	IEC 60255-21-3	Class 1 : Axis H : 3,5mm – 2g Axis V : 3,5mm – 1g
		Classe 2 : Acceleration : 2g Displacement : 7,5mm selon axe H Acceleration : 1g Displacement : 3,5mm selon axe V
Damp Heat Test - Operating	IEC 60068-2-3	Test Ca : +40°C / 10 days / 93% RH
Cold Test - Operating	IEC 60068-2-1	Test Ab : -10°C / 96h
		Test Ab : - 25°c / 96 H
Cold Test - Storage	IEC60068-2-1	Test Ad : -40°C / 96h Powered On at –25°C (for information) 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 : +70°C / 96h Powered On at +70°C
Enclosure Protection	IEC 60529	Front : IP=52 Rear : IP=30
Inrush current (start-up)		T < 1,5 ms / I < 20 A T < 150 ms / I < 10 A T > 500 ms / I < 1,2 In
Supply variation	IEC 60255-6	Vn +/- 20% Vn+30% & Vn-25% for information
Overvoltage (peak withstand)	IEC 60255-6	1,32 Vn max 2 Vn during 10 ms (for information)
Supply interruption	IEC 60255-11	From 2,5 ms to 1 s at 0,8 Vn 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 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 50 ms at Vn, no malfunction (for information
Frequency fluctuations	IEC 60255-6	50 Hz : from 47 to 54 Hz 60 Hz : from 57 to 63 Hz
Voltage withstand		2 Vn during 10 ms (for information)
High Frequency Disturbance	IEC 60255-22-1 IEC 61000-4-12 IEEE C37.90.1	Class 3 : 2.5kV (CM) / 1kV (DM)
		Class 2 : 1kV (CM)
Electrostatic discharge	IEC 60255-22-2 IEC 61000-4-2	Class 4 : 8kV contact / 15 kV air
Radiated Immunity	IEC 60255-22-3 IEC 61000-4-3	Class 3 : 10 V/m – 80 to 1000 MHz & spot tests
	IEEE C37.90.2	35 V/m – 25 to 1000 MHz

Fast Transient Burst	IEC 60255-22-4 IEC 61000-4-4 IEEE C37.90.1	Class 4 : 4kV – 2.5kHz (CM & DM)
		Class 3 2 kV - 2,5 kHz MC
		Class 3 : 2kV – 5kHz (CM)
Surge immunity	IEC 61000-4-5	Class 4 : 4kV (CM) – 2kV (DM)
		Class 3 : 2kV (CM) on shield Class 4 : 4kV (CM) for information
		Class 3 : 1 kV MC
High frequency conducted immunity	IEC 61000-4-6	Class 3 : 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 : 50 Hz – 30 A/m permanent – 300 A/m short time
		Class 5 : 100A/m for 1mn 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

V**oltage 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.

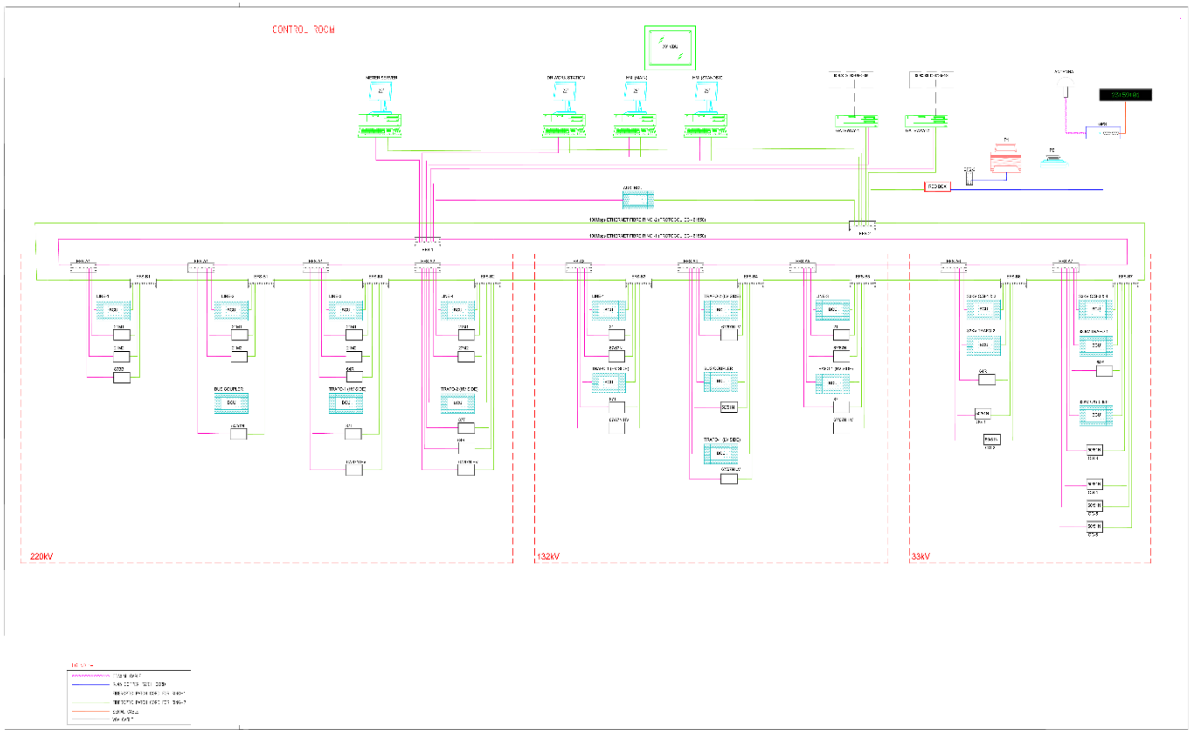
Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole during the pre-commissioning and commissioning periods. The test 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	
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	
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				

B	Configuration of Digital Channels for 32 channels				
S.No.	Channel Description	(Limited to 16 Characters)	7 characters	Triggers	COMMENTS
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
22	SPI	OTI B PH ALARM	Y
23	SPI	OTI SPARE ICT ALARM	Y

REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
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	
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	

REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
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
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

REQUIRED SIGNALS FOR ICT REF RELAYS			
SL. NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**
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		
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		

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**	**ADDITIONAL REMARKS**
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		
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		

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**	**ADDITIONAL REMARKS**
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				
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

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	**TYPE**	**EVENT/ALARM NAME**	**WHETHER ALARM TO BE GENERATED**	**ADDITIONAL REMARKS**
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.

3.27 TECHNICAL SPECIFICATION ACSR CONDUCTORS AND ACCESSORIES FOR CONDUCTORS

3.27.1.0 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.

3.27.2.0 POWER CONDUCTOR

3.27.2.1 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.

3.27.2.2 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.

3.27.2.3 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.

3.27.2.4 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.

3.27.2.5 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.

3.27.2.6 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.

3.27.2.7 REJECTION AND RETESTS

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

3.27.2.8 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.

3.27.2.9 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 (Ω/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 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

3.28 TECHNICAL SPECIFICATION FOR CONSTRUCTION WORKS IN SUBSTATIONS

3.28.1.0 GENERAL

3.28.1.1 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.

3.28.1.2 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.

3.28.1.3 A set of drawings are enclosed for reference of the Bidder. The drawings shall be treated as for bidding purpose only.

3.28.1.4 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.

3.28.1.5 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.

3.28.2.0 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.

3.28.2.2 A surface course of minimum 100 mm thickness of 20 mm nominal size river pebbles or (single size ungraded) broken stone shall be spread.

3.28.3.0 Transformer Foundation and Oil Recovery System

3.28.3.1 The Contractor shall provide an oil recovery system for all power transformers containing insulating oil, integrated with the transformer foundations.

3.28.3.2 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.

3.28.3.3 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.

3.28.3.4 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.

3.28.3.5 Transformers shall be mounted on a rail fitted on top of the foundation for its easy removal from foundation/oil collection pit.

3.28.4.0 Cable Trenches and Cable Trays
3.28.4.1 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.

3.28.4.2 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.

3.28.4.3 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.

3.28.4.4 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.

3.28.4.5 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.

3.28.4.6 Cable trench inside the Control Room shall be covered with 6 mm thick chequered plates with lifting arrangement.

3.28.4.7 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.

3.28.4.8 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.

3.28.4.9 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.

3.28.4.10 All metal parts inside the trench shall be connected to the earthing system.

3.28.4.11 Cables from trench to equipment shall run in hard conduit pipes.

3.28.4.12 Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.

3.28.4.13 The trench bed shall have a slope of 1/500 along the run and 1/250 perpendicular to the run.

3.28.4.14 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.

3.28.4.15 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.

3.28.5.0 Foundation and RCC Construction

3.28.5.1 General

3.28.5.1.1. 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.

3.28.5.1.2. 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.

3.28.5.1.3. 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.

3.28.5.1.4. The switchyard foundation's plinths and building plinths shall be minimum 300 mm and 500 mm above finished ground level respectively.

3.28.5.1.5. 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.

3.28.5.1.6. 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.

3.28.5.1.7. 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.

3.28.5.1.8. 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.

3.28.5.2 Design

3.28.5.2.1. 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.

3.28.5.2.2. Limit state method of design shall be adopted unless specified otherwise in the specification.

3.28.5.2.3. 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.

3.28.5.2.4. 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.

3.28.5.2.5. 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.

3.28.5.2.6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

3.28.5.2.7. 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.

3.28.5.2.8. RCC columns shall be provided with rigid connection at the base.

3.28.5.2.9. 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.

3.28.5.2.10. 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.

3.28.5.2.11. 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.

3.28.5.2.12. 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.

3.28.5.2.13. 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.

3.28.5.2.14. The foundations of transformer and circuit breaker shall be of block type foundation. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

3.28.5.2.15. 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.

3.28.5.3 Admixtures & Additives
3.28.5.3.1 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.

3.28.5.3.2 Admixtures in concrete shall conform to IS: 9103. The water proofing cement additives shall conform to IS: 2645. Employer shall approve concrete Admixtures/Additives.

3.28.5.3.3 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.

3.28.5.3.4 The water reducing set-retarding admixture shall be an approved brand of Ligno sulphonate type admixture.

3.28.5.3.5 The water proofing cement additives shall be used as required/advised by the Employer.

3.28.6.0 Bus Bars and Bus Bar Supports
3.28.6.1.1 The bus bars shall be outdoor strung bus bars with ACSR conductor supported on lattic.

3.28.6.1.2 If asked for, the substation steel structures shall be designed as per Section-3 of this specification.

3.28.7.0 ACSR Conductors

3.28.7.1 The Conductor shall conform to IS: 398 (latest edition) except where otherwise specified herein.

3.28.7.2 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 St: 7/ 3.53 mm	Al: 54/ 3.18 mm St: 7/ 3.18 mm	Al: 30/ 3.00 mm 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

3.28.8.0 Electrical Clearances

3.28.8.1 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

3.28.9.0 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.

3.28.9.2 General

3.28.9.2.1 GI flats of size 25 mm X 6 mm shall be used for all risers.

3.28.9.2.2. 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.

3.28.9.2.3. 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.

3.28.9.2.4. 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.

3.28.9.2.5. All metallic supporting structures and non-current carrying metallic parts of all equipment shall be provided with double earthing.

3.28.9.2.6. 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.

3.28.9.2.7. All metallic parts in cable trenches shall also be connected to the earth mat.

3.28.9.2.8. 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.

3.28.9.3 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

3.28.10.0 Protection Against Direct Lightning

3.28.10.1 Protection against direct lightning shall be provided by stringing 7/3.66 mm G.I. wires conforming to IS 2141.\

3.28.10.2 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

3.28.11.0 Bay Marshalling Kiosks

3.28.11.1 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.

3.28.12.0 Insulator and Hardware Fittings

3.28.12.1 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.

3.28.12.2 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

3.28.12.3 Parameters

3.28.12.3.1 Disc Insulators

a)	Type	: Ball and Socket
b)	Color	: 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.

3.28.12.3.2. 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

3.28.13.0 Clamps, Connectors and Spacers

3.28.13.1 Clamps and connectors shall conform to IS 2121 unless otherwise mentioned hereunder.

3.28.13.2 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).

3.28.13.3 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.

3.28.13.4 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.

3.28.14.0 Supply of Construction Materials by The Contractor

3.28.14.1 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.

3.28.14.2 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.

3.28.14.3 **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.

3.28.15.0 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.

3.28.16.0 Miscellaneous General Requirements

3.28.16.1 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.

3.28.16.2 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.

3.28.16.3 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.

3.28.16.4 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.

3.28.16.5 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.

3.28.16.6 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.

3.28.16.7 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.

3.28.16.8 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.

3.28.16.9 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.

3.28.16.10 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.

3.28.16.11 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.

3.28.16.12 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.