

**BIDDING DOCUMENT
FOR**

**“Supply, ETC and Associated Works for Augmentation of 2x100 MVA,
220/132 KV Rangia GSS By 2x200 MVA Auto-Transformer (Phase-II)”**

ASSAM ELECTRICITY GRID CORPORATION LIMITED



Volume-II

**Bid Identification No:
AEGCL/MD/TECH-1218/2025-26/BID(R-PART-2)**

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, Delivery at Site, Including Insurance During Transit, Subsequent Storage of bay equipment and accessories, Dismantling and Dragging of Existing Transformer, Erection, Testing and Commissioning of New Transformer and Associated Equipment including Civil and Related Works in the existing Rangia GSS on Turnkey basis 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 BoQ.*

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: Below 1000 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.

- 3.4.2. The Contractor shall also comply with the Minimum Wages Act 1948, Payment of Wages Act (both. of the Government of India and State of Assam), EPF, ESI, and Contract Labour (Regulation & Abolition) Act 1970 and other applicable Laws, Rules and Regulations made in respect of any employee or workman employed or engaged by him or his Sub-Contractor.
- 3.4.3. All registration and statutory inspection fees, if any, in respect of his work pursuant to this Contract shall be to the account of the Contractor.

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 up to-date valid Trade/Labour License, ESIC registration, EPFO Certificate.
- 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.
- 3.6.3. Copies of valid Electrical License for working in 132kV or above transmission lines issued by competent authority in the State of Assam or in the State where the bidder's business is registered or the bidder has to submit a declaration to obtain electrical License post award of the contract.

GENERAL TECHNICAL REQUIRMENT (GTR)

3.7.1.1 GENERAL

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

3.7.1.2 SYSTEM PARAMETERS

S. No.	Description of Parameters	400KV System	220KV System	132KV System	33 KV System
1.	System Operating Voltage	400 KV	220 KV	132 KV	33 KV
2.	Maximum operating voltage of the system (rms)	420 KV	245 KV	145 KV	36 KV
3.	Rated Frequency	50 Hz	50 Hz	50 Hz	50 Hz

4.	No. of phase	3	3	3	3
5.	Rated Insulation levels				
i	Full wave impulse withstand voltage (1.2/50 Microsecs.)	1425 kVP	1050kVP	650 kVP	250 kVP / 170 kVP
ii	Switching impulse withstand voltage (250/ 2500 micro sec.) dry and wet	1050kVP	-	-	-
iii	One-minute power frequency dry / wet withstand voltage (rms)	650 KV / 520 KV	460 KV	275 KV	95KV/ 70KV
6	Corona extinction voltage	320 KV	156 KV	105 KV	-
7	Max. radio interference voltage for frequency between 0.5MHz & 2 MHz at 508 kV rms for 765kV, 320 kV rms for 400 KV system, 156 KV rms for 220 KV system & 92 KV rms for 132 KV system	1000 microvolt	1000 microvolt	500 microvolt	
8	Minimum creepage distance @ 31 mm/KV	13020 mm	7595 mm	4495 mm	1116 mm
9	Min. Clearances				
i	Phase to spacing for installation	7000 mm	4500 mm	3000 mm	1500 mm
ii	Ground clearances from lowest live terminal of equipment from ground level	8200 mm	7000 mm	5000 mm	4000 mm
10	Rated short circuit current /for three sec. duration	63 KA for three seconds	50 KA for three seconds	40 KA for three seconds	31.5 KA for three seconds
11	System Neutral earthing	Effectively Earthed	Effectively Earthed	Effectively Earthed	Effectively Earthed

3.7.2DESIGN AND STANDARDISATION

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

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

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

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

The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expense. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements and shall be used throughout the design. All joints and fastenings shall be so devised, constructed and documented that the component parts shall be accurately positioned and restrained to fulfil their required function.

All outdoor apparatus and fittings shall be designed so that water cannot collect at any point. Grease lubricators shall be fitted with nipples and where necessary for accessibility, the nipples shall be placed at the end of extension piping. All water and oil pipe flanges shall be to IS 6392/BS 4504 or other equivalent standard, as regards both dimensions and drilling, unless otherwise approved.

Cast iron shall not be used for chambers of oil filled apparatus or for any part of the equipment which is in tension or subject to impact stresses.

Kiosks, cubicles and similar enclosed compartments shall be adequately ventilated to restrict condensation. All contractor or relay coils and other parts shall be suitably protected against corrosion.

All apparatus shall be designed to obviate the risk of accidental short circuit due to animals, birds, insects, mites, rodents or micro-organisms.

Corresponding parts shall be interchangeable. Where required by AEGCL the Contractor shall demonstrate this quality.

3.7.3QUALITY ASSURANCE

3.7.3.1 General

To ensure that the supply and services under the scope of this Contract, whether manufactured or performed within the Contractor's works or at his Sub-Contractor's premises or at Site or at any other place of work are in accordance with the Specification, with the Regulations and with relevant Indian or otherwise Authorized Standards the Contractor shall adopt suitable Quality Assurance Programmes and Procedures to ensure that all activities are being controlled as necessary.

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

The systems and procedures which the Contractor will use to ensure that the Works comply with the Contract requirements shall be defined in the Contractor's Quality Plan for the Works.

The Contractor shall operate systems which implement the following:

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

AEGCL written approval is required to authorize work to progress beyond the Hold Points indicated in approved Quality Plans.

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

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

3.7.3.2 Quality assurance programme

Unless the Contractor’s Quality Assurance System has been audited and approved by AEGCL, a Quality Assurance Program for the Works shall be submitted to AEGCL for approval a minimum of one month prior to commencement of the works, or such other period as shall be agreed upon by AEGCL. The Quality Assurance Program shall give a description of the Quality System for the Works and shall, unless advised otherwise, include details of the following:

- The structure of the Contractor’s organisation
- The duties and responsibilities assigned to staff ensuring quality of work
- The system for purchasing, taking delivery and verification of materials
- The system for ensuring quality of workmanship
- The system for the control of documentation
- The system for the retention of records
- The arrangements for the Contractor’s internal auditing
- A list of the administration and work procedures required to achieve and verify the Contract’s Quality requirements. These procedures shall be made readily available to AEGCL for inspection on request.

3.7.3.3 Quality plans

The Contractor shall draw up for each section of the work Quality Plans which shall be submitted to AEGCL for approval at least two weeks prior to commencement of the particular section. Each Quality Plan shall set out the activities in a logical sequence and, unless advised otherwise, shall include the following:

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

3.7.3.4 Inspection and testing

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

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

3.7.3.5 Non-conforming product

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

3.7.3.6 Monitoring of quality arrangements

During the course of the Contract AEGCL may monitor the implementation of the Quality Assurance arrangements. Monitoring will be by surveillance of the activities at work locations and/or by formal audits of the adherence of the

Contractor to the systems and procedures which constitute his Quality Assurance arrangements. Corrective actions shall be agreed and implemented in respect of any deficiencies.

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

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

3.7.3.7 Method statement

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

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

3.7.4 HEALTH, SAFETY AND ENVIRONMENT (HSE) PLAN

3.7.4.1 General

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

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

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

Special arrangements shall be made to accommodate for gender-inclusive engagements and participation of vulnerable people, to ensure the implementation of the social development and gender relevant features included in the design of the project, including monitoring of occupational and community health and safety, community awareness activities, compliance of core labour standards, prevention of Gender-based violence (GBV) and Sexual exploitation (SE) risks.

3.7.4.2 Content of HSE Plan

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

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

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

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

3.7.4.3 General structure of HSE Plan

The HSE Plan shall conform to the following general structure:

1. Contractors Policy Statement
2. Health
 - 2.1 First Aid
 - 2.2 Primary health care
 - 2.3 Occupational and community health
3. Safety

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

3.7.4.4 Section 6 of HSE Plan

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

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

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

3.7.5. PROGRESS REPORTING

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

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

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

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

3.7.6. STANDARDS

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

The supply and erection requirements and procedures to be followed during the installation of the equipment shall be in accordance with the relevant Indian/International Standards/Regulations, ASME codes, accepted good engineering practice, drawings and other applicable Indian codes and laws and regulations.

Reference to a particular standard or recommendation in this Specification does not relieve the Contractor of the necessity of providing the Contract Works complying with other relevant standards or recommendations.

The list of standards provided in the Chapter 1 of this Specification is not to be considered exhaustive and the Contractor shall ensure that equipment supplied under this contract meets the requirements of the relevant standard whether or not it is mentioned therein.

3.7.7. LANGUAGE AND SYSTEM OF UNITS

The English language shall be used in all written communications between the Employers, AEGCL and the Contractor with respect to the services to be rendered and with respect to all documents and drawings procured or prepared by the Contractor pertaining to the work, unless otherwise agreed by the Employer.

It is required that danger plates, equipment designation labels or plates, instruction notices on plant and general substation notices be written in English. Control switch and lamp labels, indicator lamp and annunciator inscriptions shall be in English only.

The design features of all equipment shall be based on the SI system of units.

3.7.8. MASS AND SIZE OF PARTS AND QUANTITIES OF OIL

The mass and dimensions of any item of equipment shall not exceed the figures stated in the Schedules.

Each item shall be labeled to indicate its mass, quantity of oil (if any) and any special handling instructions.

3.7.9. GENERAL REQUIREMENTS

3.7.9.1 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/132kV Class Equipment					
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	Dark violet	796	—	—
	220kV	Golden yellow	356	—	—
	132kV	Sky blue	101	—	—
	33kV	Signal red	537	—	—
	11kV	Canary yellow	309	—	—
	415V	Middle brown	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 lamicaid. 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 arc 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

3.7.16.6.1 General 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, Disconnecter, 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.

3.7.16.7 FIRE 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.

3.7.16.8 PACKING, 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 $100A/mm^2$. Single connections between equipment and the earth system shall carry the total short circuit current, but the cross-sectional area of branch connections may be reduced to take account of current distribution in two or more conductors. A distribution of 60 per cent shall be assumed for this purpose, i.e. the cross-sectional area of branch connections may be reduced to 60 per cent of the corresponding single conductor.

The earth conductor may be sized as per IEEE 80 and sufficient allowance for corrosion may be taken into account.

The grid voltage rise under fault conditions shall not exceed 15 kV. If the calculated grid voltage rise exceeds 430V, the local Telephone Authority shall be advised, by the Contractor, of the grid voltage rise and the distance of the 650V contour from the substation grid periphery.

The alternative approach of independently earthing the fence and placing it outside the earth grid area shall only be adopted if the above-mentioned procedures prove insufficient or impracticable. The Contractor shall provide calculations to show that this approach produces safe touch voltages at the fence and shall ensure that the fence is isolated from all other buried metalwork.

Metal parts of all equipment, other than those forming part of an electrical circuit, shall be connected directly to the main earth system at two points. For the same the size of the G.I. flats shall also be 75X10mm. This is the raiser of the earth to the structures of column, beam and all equipment structures. The arrangement of the mesh earth system shall be such as to minimise the length of these connections.

A separate set of earth electrodes (at least two), GI pipe, perforated, 50mm dia, heavy duty having 3000mm long in a treated earth pit, shall be provided for the earthing for high frequency coupling equipment (CVT etc), surge arresters, IVT, each neutral of the transformers and reactors at a position immediately adjacent to the equipment being earthed in addition to the normal earth connection.

All main members of structural steelworks shall be earthed by GI flat (size 75X10mm) earthing connections being bonded to the steelworks. The Contractor shall be responsible for earthing of the transformers and circuit breakers installed on the substation site as per recommended.

Connections to apparatus and structures shall be made clear of ground level, preferably to a vertical face and protected against corrosion.

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

All exposed joints shall be at a minimum height of 150 mm above floor or ground level.

A facility shall be provided on the earth bar run between the equipment and the base of the structure, comprising a looped copper strip (test link), so as to permit the attachment of portable earth connections for maintenance purposes. After installation of the earth system the Contractor shall measure the resistance of the substation. The method used shall preferably be the "fall of potential" method, requiring the availability of a local low voltage supply, but other methods using an earth resistance meter will be acceptable in the event of a local supply being unavailable.

The fencing of the switch yard also to be earthed by using G.I flats of size 75x10mm to each post and a continuous earth strip of size 50x6mm shall run all through the fence. The periphery of the switch yard shall be provided with non-treated earth pit at a distance of 5 mtrs all along the periphery. The size of the non-treated pit conductor shall be 40 mm dia MS rod of length 3000mm. The said earth MS Rod to be placed in earth pit as per standard practice and the pit shall be filled with Bentonite powder mixed with lomy soil at a ratio 1:10. There shall be provision of watering into the earth pits. A pipe of adequate size should run all along the periphery and outlets shall be provided to each pit. The pipe shall be connected to the overhead tank provided on the control room building and proper water control valve should be provided. Contractor shall prepare a detail earthing provision considering as per specification and shall obtain approval from AEGCL and the top of the MS rod shall be welded to the buried earth mats.

3.17. TECHNICAL SPECIFICATION OF TRANSFORMER (NOT APPLICABLE FOR THIS BID)

3.18. TECHNICAL SPECIFICATION OF SF6 Circuit Breaker (Up to 400 kV)

The intention of this Section of the Specification is to cover design, manufacture, testing at manufacturer's works and supply Circuit Breakers with all fittings and accessories as per BoQ and as specified hereunder.

3.18.1.0 GENERAL

3.18.1.1 The circuit breakers and accessories shall conform to latest revision of IEC: 62271-100, IEC: 62271-1 and other relevant IEC standards except to the extent explicitly modified in the specification and shall also be in accordance with requirements specified in GTR.

3.18.1.2 420/245/145/72.5kV circuit breakers offered would be of Sulphur hexafluoride (SF6) type and of class C2-M2 as per IEC. The bidder may offer circuit breakers of either live tank type of proven design.

3.18.1.3 The circuit breaker shall be complete with operating mechanism, common marshalling box, piping, inter-pole cables, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure, platform with ladder for CB, their foundation bolts and all other accessories required for carrying out all the functions of the CB.

All necessary parts to provide a complete and operable circuit breaker installation such as terminal pads, control parts and other devices shall be provided.

3.18.1.4 Painting shall be done in line with GTR. Paint shade RAL-7032 or similar shades can be used for painting. The support structure, platform & ladder of circuit breaker shall be hot dip galvanised. Exposed hardware items shall be hot dip galvanised or Electro-galvanised.

3.18.1.5 The circuit breakers shall be designed for use in the geographic and meteorological conditions as given Below:

- | | | |
|----|---|---|
| a) | Peak ambient day temperature in still air | : 45°C |
| b) | Minimum night temperatures | : 0°C |
| c) | Ground temperatures | : 40°C |
| d) | Reference ambient day temperature | : 45°C |
| e) | Relative Humidity | a) Maximum : 100 %
b) Minimum : 10 % |
| f) | Altitude | : Below 1000 M above MSL |
| g) | Maximum wind pressure | : As per IS: 802 latest codes. |
| h) | Seismic Intensity | : ZONE-V as per IS 1893. |

3.18.1.6 All 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD by using a suitable selector switch irrespective of whether circuit breakers to be supplied are envisaged along with CSD or not as per bid price schedules.

3.18.2.0 DUTY REQUIREMENTS

3.18.2.1 The circuit breakers shall be capable of performing their duties without opening resistors.

3.18.2.2 The circuit breaker shall meet the duty requirements for any type of fault or fault location and also for line switching when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

3.18.2.2.1 PRE-INSERTION RESISTER

420kV circuit breakers shall be provided with single step pre- insertion closing resistors (wherever the requirement of PIR is explicitly specified in bid price schedules) to limit the switching surges. The resistance value of pre-insertion resistor and the duration of pre-insertion time is given in **clause 3.18.19** of this section.

The resistor shall have thermal rating for the following duties:

i) TERMINAL FAULT

Close 1 Min Open Close Open.....2 min Close 1 Min
Open Close Open.

ii) RECLOSING AGAINST TRAPPED CHARGES

Duty shall be the same as under (i) above. The first, third and fourth closures are to be on de-energised line while second closing is to be made with lines against trapped charge of 1.2 p.u. of opposite polarity.

iii) OUT OF PHASE CLOSING

One closing operation under phase opposition, that is with twice the voltage across the terminals.

iv) No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor support shall perform all these duties without deterioration. Test reports of resistors proving thermal rating for duties specified above shall be furnished during detailed engineering. The calculations shall be provided to take care of the effect of tolerances on resistance values and insertion time.

3.18.2.3 The breaker shall be capable of:

i) Interrupting the steady and transient magnetizing current corresponding to Power transformers as follows:

Voltage rating of CB	Type of Transformer	Rating (in MVA)
420kV	400/220kV	250 to 630
	400/132kV	160 to 315
245kV	400/220kV	200 to 630
	220/132kV	50 to 200
	220/66kV	50 to 200
145kV	220/132kV	50 to 200
	132/33kV	10 to 50

ii) Interrupting line/cable charging current as per IEC without use of opening resistors. The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of $U/\sqrt{3}$ and 1.4

iii) Clearing short line fault (kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

iii) Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.

iv) Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e., shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).

v) Circuit breakers shall be able to switch in and out the shunt reactor as detailed below:

Voltage rating of CB	Reactor Rating (n MVAR)	Max. rise of over voltage (in p.u.)
420kV	50 to 150	2.3
245kV	25 to 50	2.3

a. Capability of 400 kV circuit breakers to interrupt inductive current below 100 A without giving rise to overvoltage more than 2.3 p.u. (As specified in IEC-62271-110) shall be validated by carrying out the simulation study/analysis (EMTP/PSCAD) by modeling an equivalent circuit comprising all circuit component i.e. Inductance of Shunt Reactor, Stray capacitance of Shunt Reactor, Circuit Breaker, Stray capacitance of Bus Connection, Capacitance of grading Capacitor, inductance of neutral grounding reactor, Network Thevenin's equivalent, any other series/parallel inductance/capacitance connected to simulate the actual inductive load switching.

- b. Current chopping capability (chopping number) of circuit breakers as per IEC-62271-306 to be figured out from actual Laboratory test and / or field test report and same Current chopping capability (chopping number) shall be used in above said simulation study/analysis.
- c. To validate the results of above said simulation study/analysis report, the same study shall be carried out for capability of tested circuit breaker and the study/analysis results shall be comparable with actual Laboratory test and / or field test reports.
- d. Laboratory test/ field test reports shall be submitted for 400 kV CBs in case there is change in design including change in following:
 - i. Different short circuit current capability
 - ii. Different model/type
- vi) The breakers shall also withstand the voltages specified under **clause 3.18.19** of this section.

3.18.3 CONTROLLED SWITCHING DEVICE (CSD):

Circuit Breakers shall be equipped with controlled switching device with consequent optimization of switching behavior, when used in:

3.18.3.1 Switching of transformer (from 400kV side circuit breakers only)

3.18.3.2 Switching of shunt Reactor

The CSD shall be provided in Circuit breaker of switchable line reactor bay and in Main & Tie Bay circuit breakers of Transformers, line with non- switchable line reactors and Bus reactors. The CSD shall be supplied as per bid price schedules.

3.18.3.3 Technical Requirement for controlled switching device:

- a) The CSD shall be designed to operate correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified in section - GTR.
- b) The CSD shall meet the requirements of IEC-61000-4-16 class IV for HF disturbance test (for short and long durations both) and fast transient test shall be as per IEC-61000-4-4 level IV and insulation test as per IEC 60255-5.
- c) The CSD shall have functions for switching ON & OFF the circuit breakers.
- d) The CSD shall get command to operate the breakers manually. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs & CVTs for the purpose of calculation of optimum moment of the switching the circuit breaker and issue command to circuit breaker to operate.
- e) The CSD shall also have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing the switching command. In calculation of next operating time of the breaker, the CSD must consider all factors that may affect the operating time of the breaker such as, but not limited to, ambient temperature, control voltage variation, SF6 gas density variations etc. Schematic drawing for this purpose shall be provided by the contractor. The accuracy of the operating time estimation by the controller shall be better than ± 0.5 ms.
- f) The CSD should have display facility at the front for the display of settings and measured values.
- g) The CSD shall be PC compatible for the setting of various parameters and down loading of the settings and measured values, date, time of switching etc. Window based software for this purpose shall be supplied by the contractor to be used on the owner's PC.

- h) The controller shall be suitable for current input of 1 ampere from the secondary of the CTs. and 110 V (Ph to Ph) from the CVTs. The CSD shall withstand transient and dynamic state values of the current from the secondary of the CTs and CVTs.
- i) The CSD shall have time setting resolution of 0.1 ms or better.
- j) The CSD shall have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room. Necessary details shall be worked out during engineering of the scheme.
- k) The CSD shall also record and monitor the switching operations and make adjustments to the switching instants to optimize the switching behavior as necessary. It shall provide self-diagnostic facilities, signaling of alarms and enable downloading of data captured from the switching events.
- l) The provision for bypassing the Controlled switching device shall be provided through BCU and SCADA both so that whenever, the CSD is not healthy due to any reason (including auxiliary supply failure), uncontrolled trip/close command can be extended to the circuit breaker. Alternatively, in case of any non-operation of the CSD after receiving a close/trip command after a pre-determined time delay, the CSD should automatically be bypassed so as to ensure that the trip and close commands are extended to the Trip/Close coils through subsequent command.
- m) The CSD shall be provided with a communication port to facilitate online communication of the CSD with Substation automation system directly on IEC 61850 protocols. If the CSD does not meet the protocols of IEC 61850, suitable gateway shall be provided to enable the communication of CSD as per IEC 61850.

3.18.4 TOTAL BREAK TIME

The total break time as specified under this section shall not be exceeded under any of the following duties:

3.18.4.1 Test duties T10, T30, T60, T100a, and T100s (with TRV as per IEC:62271-100)

3.18.4.2 Short line fault L75, L90 (with TRV as per IEC: 62271-100)

The total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the effect of non-simultaneity between contacts within a pole or between poles shall be brought out to establish guaranteed total break time.

The values guaranteed shall be supported with the type test reports.

3.18.5 CONSTRUCTIONAL FEATURES

The features and constructional details of circuit breakers shall be in accordance with requirements stated hereunder:

CONTACTS

3.18.5.1 The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero-gauge pressure of SF₆ gas due to the leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e., 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric withstand test conducted for a duration of at least 15 minutes is acceptable).

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

Calculations/ test reports in support of the same shall be furnished. The thermal and voltage withstand rating of the grading elements shall be adequate for the service conditions and duty

specified.

3.18.6 The SF6 Circuit Breaker shall meet the following additional requirements:

- a) The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a 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.
- b) 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 0.5% per year and the leakage rate shall be guaranteed during the warranty period. In case the leakage under the specified conditions is found to be greater than 0.5% per year after commissioning of circuit breaker during the warranty period, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during the warranty period.
- c) In the interrupter assembly there shall be an absorbing product box to minimise the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF6 gas decomposition products.
- d) Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 420 & 245 kV CBs) and the SF6 density of each pole shall be monitored individually. For CBs of voltage class of 145 kV or less, a common SF6 scheme/density monitor shall be acceptable.
- e) The dial type SF6 density monitor shall be adequately temperature compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. Separate density monitors and dial type temperature compensated pressure gauge is also acceptable. The density monitor shall have graduated scale and it shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by providing suitable interlocked non return valve coupling.
- f) Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.
- g) Sufficient SF6 gas (including that will be required for gas analysis during filling) shall be provided to fill all the circuit breakers being supplied. Spare gas shall be supplied in separate unused cylinders as per requirement specified in BPS.
- h) Provisions shall be made for attaching an operational analyser to record contact travel, speed and making measurement of operating timings, preinsertion timings of closing resistors if used, synchronization of contacts in one pole.
- i) The CO (Close-open) operation and its timing shall be such as to ensure complete travel/insertion of the contact during closing operation and then follow the opening operation.

3.18.7 SULPHUR HEXAFLUORIDE GAS (SF6 GAS)

- 3.18.7.1** The SF6 gas shall comply with IEC 60376 and shall be suitable in all respects for use in the switchgear under the operating conditions.
- 3.18.7.2** The high-pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations. SF6 gas shall be supplied (in returnable cylinders) for all circuit breakers. However, SF6 gas for spare circuit breakers and mandatory spare quantity of SF6 gas shall be supplied in non-returnable cylinders.
- 3.18.7.3** Test: SF6 gas shall be tested for purity, dew point, air, hydro-soluble fluorides and water content as per IEC 60376 and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas and Material safety datasheet shall be provided. Gas bottles should be checked for leakage during receipt at site.

3.18.8 INSULATORS

- 3.18.8.1** The porcelain/polymer of the insulators shall conform to the requirements stipulated under Section-GTR.
- 3.18.8.2** The mechanical characteristics of insulators shall match with the requirements specified under this section.
- 3.18.8.3** All porcelain & polymer hollow column insulators shall conform to IEC-62155 & IEC-61462

respectively.

- 3.18.8.4** Hollow Porcelain/polymer for pressurized columns/chambers should be one integral piece in green and fired stage.

3.18.9 SPARE PARTS AND MAINTENANCE EQUIPMENT

The bidder shall include in his proposal, spare parts and maintenance equipment in accordance with BPS. Calibration certificates of each maintenance equipment shall be supplied along with the equipment.

3.18.10 OPERATING MECHANISM AND CONTROL

General Requirements

- 3.18.10.1** Circuit breaker shall be operated by spring charged mechanism. The mechanism box shall meet the requirements of IP-55.
- 3.18.10.2** The operating mechanism box shall be strong, rigid, rebound free and shall be readily accessible for maintenance.
- 3.18.10.3** The mechanism shall be anti-pumping and trip free under every method of closing.
- 3.18.10.4** The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause unwanted trip or closing operation of the Circuit Breaker
- 3.18.10.5A** A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the common marshalling box.
- 3.18.10.6** Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.
- 3.18.10.7** The contractor shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker. The instruction manuals shall contain exploded diagrams with complete storage, handling, erection, commissioning, troubleshooting, servicing and overhauling instructions.
- 3.18.10.8** Size of common marshalling Box shall be such that adequate space is available for working in the panel and all wiring shall be routed through non-flammable wire troughs with covers.
- 3.18.10.9** Operating mechanism and Marshalling box should be provided with space heater with thermostat, CFL/LED lamp and AC point /Socket.

3.18.11 Control

- 3.18.11.1** The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.
- 3.18.11.2** Each breaker shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources.
- 3.18.11.3** The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose, a local/remote selector switch and close and trip control switch/push buttons shall be provided in the Breaker common marshalling box.
- 3.18.11.4** The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker.
- 3.18.11.5** Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip coil and associated circuits shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage. However, even at 50% of rated voltage the breaker shall be able to open. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on outdoor circuit breakers shall be clearly brought out during detailed engineering.
- 3.18.11.6** In trip and closing circuits, relays/relay contacts shall preferably be used instead of contactors.
- 3.18.11.7** Controlled switching scheme/device, wherever required shall be considered as integral part of CB and shall be commissioned along with CB.

3.18.11.8 Density Monitor contacts and pressure switch contacts shall be preferably suitable for direct use as permissive in closing and tripping circuits. The devices shall provide continuous & automatic monitoring of the state of the gas as follows:

3.18.11.8.1 'Gas Refill' level

This contact will be used for remote indication/ to annunciate the need for gas refilling.

3.18.11.8.2 'SF6 gas density Low' Alarm level - 1

This contact will be used for remote indication/ to annunciate the need for the urgent gas refilling.

3.18.11.8.3 'SF6 gas density Low' Alarm level - 2

This contact will be used to annunciate the need for gas refilling under emergency or trip the Circuit Breaker.

3.18.11.8.4 'Breaker Block' level

This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the breaker block contact shall operate & the tripping & closing circuit shall be blocked.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

The density monitor shall be placed suitably inclined in such a way so that the readings are visible from ground level with or without using binoculars. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail-safe logic/schemes are to be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations and operation lockout in case of D.C. failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit Breaker.

3.18.11.9 The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

3.18.12 Spring operated mechanism:

- a) Spring operated mechanism shall be complete with motor as per manufacturer practice. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.
- b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.
- c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.
- d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring.
- e) Closing action of circuit breaker shall compress the opening spring ready for tripping.
- f) When closing springs are discharged after closing a breaker, closing springs shall be automatically charged for the next operation and an indication of this shall be provided in the local and remote-control cabinet.
- g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.
- h) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.
- i) The spring charging failure alarm shall be provided with a time delay relay having setting

range from 0-1minute.

- j) Separate MCBs shall be provided for each spring charging motor and the rating of MCBs shall be suitably selected to match the starting, running and stalling time.
- k) An overload relay shall be provided for protection of the spring charging motor.

3.18.13 SUPPORT STRUCTURE

3.18.13.1 The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

3.18.13.2 Ladder and Maintenance platform for 400kV Circuit breaker:

A suitable ladder with the safety cage and a free-standing maintenance platform with railing for each pole of the circuit breaker shall be supplied along with the equipment and its supportstructure. The platform shall be suitable for maintenance personnel to stand and carry out the activities along with the tools and plant.

The ladder cum maintenance platform shall be designed as a free-standing structure without taking any support from the main circuit breaker structure. The ladder having height more than 3.0m shall have at least 15-degree slope and is to be provided with safety guard above 2.0m level. All structural steel for the platform shall be as per IS: 2062 and to be galvanized. For 220kV, 132kV circuit breakers a suitable platform cum ladder shall be provided as per manufacturer design.

3.18.14 TERMINAL CONNECTOR PAD

The circuit breaker terminal pads shall be made up of high-quality electrolytic copper or aluminium and shall be conforming to Australian Standard AS- 2935 or equivalent standard for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

INTER-POLE CABLING

- a) All cables to be used by contractor shall be armoured and shall be as per IS – 1554/ IEC-60502 (1100 Volts Grade). All cables within & between circuit breaker poles and its marshaling box and up to the controlled switching device is included in the scope of work. Special cables like screened cable if required for Circuit Breaker, temperature Transducer/CB Status Signals for CSD and its associated C&R panel shall be laid in 50mm diameter PVC pipe. Suitable supports for PVC pipe shall be included in the scope of Supply.
- b) Only stranded conductor shall be used. Minimum size of the conductor for inter-pole control wiring shall be 2.5 sq.mm. Copper.
- c) The cables shall be with oxygen index Minimum 29 and temperature index as 250°C as per relevant standards.
- d) Separate cables shall be used for AC, DC-I, DC-II and selected DC.
- e) All inter-pole cabling of Circuit breakers and up to common marshalling box shall be done by plug-in type arrangement. Suitable removable type encasing cover shall be provided in case plug-in type connection arrangement is provided exterior side of LCC/MB. The plug-in type cable termination shall be conforming to IP-67 as per IEC60529. Cable sealing arrangement shall be provided (as per requirement) to avoid entry of moisture etc.
- f) Vertical run of cables to the operating mechanism box shall be properly supported by providing the perforated closed type galvanized cable tray (Cable tray also to be supplied along with the Circuit Breaker) to be fixed as an integral part of the structures. The load of the cable shall not be transferred to the mechanism box/plug-in type terminal arrangement in any circumstances. Hanging or loose run of cable is not permitted. The drawing of cable tray including fixing arrangement shall be incorporated in the GA drawing of CB also.
- g) Wiring shall be done with stud type terminals and ring type lugs. More than two wires shall not be connected on each side of terminal.

3.18.15 FITTINGS AND ACCESSORIES

Following is list of some of the major fittings and accessories to be furnished by Contractor in the common marshalling box. Number and exact location of these parts shall be indicated in the drawing.

- 3.18.15.1 Cable glands (Double compression type), Lugs, Ferrules etc.
- 3.18.15.2 Local/remote changeover switch.
- 3.18.15.3 Operation counter
- 3.18.15.4 Control switches to cut off control power supply.
- 3.18.15.5 Fuses/MCBs as required.
- 3.18.15.6 The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use.
- 3.18.15.7 Anti-pumping relay.
- 3.18.15.8 Pole discrepancy relay (for electrically ganged CBs).
- 3.18.15.9 D.C. Supervision relays.
- 3.18.15.10 Rating plate description in accordance with IEC incorporating year of manufacture.
- 3.18.15.11 Controlled switching accessories like sensors, timers, relays etc. (as applicable)
- 3.18.15.12 Transducers/Fixtures required for travel measurement shall be supplied by CB manufacturer. The complete set of Transducers/Fixtures for measurement of complete 3-phase CB shall be supplied for each station. Further, one set of gas filling adopter (Including coupling, regulator, connecting hose pipe up to ground level) shall be supplied as per BPS.

3.18.16 ADDITIONAL DATA TO BE FURNISHED

- 3.18.16.1 Drawing, showing contacts in close, arc initiation, full arcing, arc extinction and open position.
- 3.18.16.2 The temperature v/s pressure curves for each setting of density monitor along with details of density monitor.
- 3.18.16.3 Method of checking the healthiness of voltage distribution devices (condensers) provided across the breaks at site.
- 3.18.16.4 Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.
- 3.18.16.5 Maximum non-simultaneity between contacts, between poles and effect of the same on the guaranteed total break time.
- 3.18.16.6 Sectional view of non-return couplings used for SF6 pipes.
- 3.18.16.7 Details & type of filters used in interrupter assembly and also the operating experience with such filters.
- 3.18.16.8 Details of SF6 gas:
 - i) The test methods used in controlling the quality of gas used in the circuit breakers particularly purity and moisture content.
 - ii) Proposed tests to assess the conditions of the SF6 within a circuit breaker after a period of service particularly with regard to moisture contents of the gas.
- 3.18.16.9 Shall furnish curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage.
- 3.18.16.10 Detailed literature and schematic diagrams of switching mechanism for closing resistor showing the duration of insertion shall also be furnished along with the calculations in respect of thermal rating of resistors for the duties specified in this section in case of 420 kV circuit breakers.
- 3.18.16.10 All duty requirements as applicable to 420 kV, 245 kV & 145 kV CBs specified under Clause 3.18.2.0 of this section shall be provided with the support of adequate test reports.

3.18.17 TESTS

- 3.18.17.1 In accordance with the requirements stipulated under Section-GTR the circuit breaker along with its operating mechanism shall conform to the type tests as per IEC: 62271-100.
- 3.18.17.2 The type test reports as per IEC and the following additional type test reports shall also be submitted for purchaser's/employer's review:
 - i. Corona extinction voltage test
 - ii. Out of phase closing test as per IEC: 62271-100.
 - iii. Line charging interrupting current for proving parameters as per **clause 3.18.19** of this section.
 - iv. Test to demonstrate the Power Frequency withstand capability of breaker in open condition

- at Zero Gauge pressure and at lockout pressure (Ref. **Clause 3.18.5.1**).
- v. Seismic withstand test unpressurised condition.
- vi. Verification of the degree of protection.
- vii. Low temperature test (applicable only for minimum ambient temperatures of less than (-) 10 deg. C application purpose) and High temperature test. Contractor can also submit the field performance report in line with IEC stipulations.
- viii. Static Terminal Load test.
- ix. Critical Currents test (if applicable).
- x. Switching of Shunt Reactors. Test reports shall be submitted as per IEC Calculations shall be submitted for meeting the requirements of **clause 3.18.2.3(v)** of this section.
- xi. Circuit breakers meant for controlled switching shall conform to requirements of IEC/TR-62271 – 302. The contractor shall submit test reports to demonstrate that the offered CB conforms to the requirements of performance verification tests and parameter definition tests as per IEC/TR 62271-302. The contractor shall also furnish the report for the re-ignition free arcing window for switching 3-phase shunt reactor as demonstrated in the shunt reactor switching test.

3.18.18 Routine Tests

Routine tests as per IEC:62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, the following tests shall also be performed.

- 3.18.18.1** Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto reclosing and trip free operation under normal as well as limiting operating control voltage conditions. The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be arranged by the contractor at his own cost.
- 3.18.18.2** During testing of CB, dynamic contact resistance measurement (DCRM) shall be carried out for close-open (CO) operations with delay of 300ms between close and trip operations. Minimum 100A current shall be injected for DCRM test. Travel characteristics, injected current, trip/close coil current shall also be recorded along with DCRM test.
- 3.18.18.3** Routine tests on Circuit breakers with Controlled switching devices as per IEC/TR 62271-302.
- 3.18.18.4** Tan delta and Capacitance measurement for grading capacitors at rated voltage and also at 10kV (for reference).

3.18.19 TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

(In addition to those indicated in section-GTR)

Sl. no.	Parameter	400kV system	220kV system	132 kV system
1.	Rated voltage (U _{max}) kV (rms)	420	245	145
2.	Rated frequency (Hz)	50	50	50
3.	No. of poles	3	3	3
4.	Type of circuit breaker	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated
5.	Rated continuous current (A) at an ambient temperature of 50°C	4000	3150	3150
6.	Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening time under operating conditions specified.	63kA	50 kA	40 kA
7.	Symmetrical interrupting capability kA (rms)	63	50	40
8.	Rated short circuit making current kAp	157.5	125	100
9.	Short time current carrying capability kA (rms)	63 for three second	50 for three second	40 for three second
10.	Out of phase breaking current carrying capability kA (rms)	15.75	As per IEC	As per IEC
11.	Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of U/√3 and 1.4 as per IEC-62271-100	600	As per IEC	As per IEC
12.	First pole to clear factor	1.3	1.3	1.3
13.	Temperature rise over an ambient temperature of 50°C	As per IEC:62271-100	As per IEC:62271-100	As per IEC:62271-100
14.	Rated break time as IEC (ms)	40	60	60
15.	Total break time (ms)	45	65	65

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16.	Total closing time (ms)	Not more than 150	Not more than 150	Not more than 150
17.	Operating mechanism or a combination of these	Spring	Spring	Spring
18.	Rated operating duty cycle	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO
19.	Reclosing	Single phase & Three phase auto reclosing.	Single phase & Three phase auto reclosing.	Three phase auto reclosing. (Single phase auto reclosing if specified in section-project)
20.	Pre-insertion resistor requirement	As per BPS	NA	NA
i)	Rating (ohms)	400(max.) with tolerance as applicable	NA	NA
ii)	Minimum electrical (mechanical insertion time + pre-arcing time) pre-insertion time (ms)	8	NA	NA
iii)	Opening of PIR contacts	PIR contacts should open immediately after closing of main contacts OR At least 5 ms prior to opening of main contacts at rated air/gas pressure where the	NA	NA
		PIR contacts remain closed		
21.	Max. difference in the instants of closing/opening of contacts (ms) between poles at rated control voltage and rated operating & quenching media pressures	2.5(within a pole) 3.3(opening) 5.0(closing)	3.3(opening) 5.0(closing)	3.3(opening), 3.3(closing)
22.	Maximum allowable switching over voltage under any switching condition	2.3 p.u.	As per IEC	As per IEC
23.	Trip coil and closing coil voltage with variation as specified	220V DC or 110VDC	220V DC or 110V DC	220V DC or 110V DC
24.	Noise level at base and up to 50 m distance from base of circuit breaker	140dB (max.)	140dB (max.)	140dB (max.)
25.	Rating of Auxiliary contacts	10A at 110/220V DC	10A at 110/220V DC	10A at 110/220V DC

26.	Breaking capacity of Aux. Contacts	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms
27.	Rated insulation levels			
i)	Full wave impulse withstand (1.2 /50 μ s) between line terminals and ground	\approx 1425 kVp	\approx 1050 kVp	\approx 650 kVp
ii)	Full wave impulse withstand (1.2 /50 μ s) between terminals with circuit breaker open	1425 kVp impulse on one terminal & 240 kVp power frequency voltage of opposite polarity on the other terminal	\approx 1050 kVp	+ 650kVp
iii)	Rated switching impulse withstand voltage (250/2500 μ s) Dry & wet between line terminals and ground	+1050 kVp	NA	NA
iv)	Rated switching impulse withstand voltage (250/2500 μ s) Dry & wet Between terminals with circuit breaker open	900 kVp impulse on one terminal & 345 kVp power frequency voltage of opposite polarity on the other terminal	NA	NA
v)	One minute power frequency dry withstand voltage between line terminals and ground	520 kV rms.	460 kV rms.	275 kV rms
vi)	One minute power frequency dry withstand voltage between terminals with circuit breaker open	610 kV rms.	460 kV rms.	275 kV rms
28.	Minimum corona extinction voltage with CB in all positions	320kV rms	156 kV rms	92 kV rms
29.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz (Micro volts)	1000 μ V (at 266kVrms)	1000 μ V (at 156kVrms)	500 μ V (at 92kVrms)
30.	Minimum Creepage distance*			
i)	Phase to ground (31mm/kV)	13020mm	7595mm	4495mm
ii)	Between CB terminals	13020mm	7595mm	4495mm
31.	System neutral earthing	Effectively earthed		
32.	Rated terminal load	As per IEC or as per the value calculated based on specific switchyard layout requirement, whichever is higher.		

33.	Auxiliary contacts	Besides requirement of technical specification, the manufacturer/contractor shall wire up 10 NO + 10 NC contacts exclusively for purchaser's use and wired up to common marshalling box.
34.	No. of terminals in common marshalling box	All contacts & control circuits to be wired out up to common marshalling box + minimum 24 terminals exclusively for purchaser's future use
35.	Seismic level	0.5g horizontal for the site location under the Zone-V as per IS-1893 0.3g horizontal for the site location under other than the Zone-V as per IS-1893

3.18.20 PRE-COMMISSIONING TESTS

An indicative list of tests is given below. All routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

- 2.21.1 Insulation resistance of each pole.
- 2.21.2 Check adjustments, if any suggested by manufacturer.
- 2.21.3 Breaker closing and opening time.
- 2.21.4 Slow and Power closing operation and opening.
- 2.21.5 Trip free and anti-pumping operation.
- 2.21.6 Minimum pick-up voltage of coils.
- 2.21.7 Dynamic Contact resistance measurement.
- 2.21.8 Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.
- 2.21.9 Insulation resistance of control circuits, motor etc.
- 2.21.10 Resistance of closing and tripping coils.
- 2.21.11 SF6 gas leakage check.
- 2.21.12 Dew Point Measurement
- 2.21.13 Operation check of pressure switches and gas density monitor during gas filling.
- 2.21.14 Checking of mechanical 'CLOSE' interlock, wherever applicable.
- 2.21.15 Testing of grading capacitor.
- 2.21.16 Resistance measurement of main circuit.
- 2.21.17 Checking of operating mechanisms
- 2.21.18 Check for annunciations in control room.
- 2.21.19 Point of wave switching test (wherever applicable)

The contractor shall ensure that erection, testing and commissioning of circuit breaker shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

3.18.21 ACTIONS REQUIRED FOR DEFECTS OBSERVED DURING DEFECT LIABILITY PERIOD

The actions required to be taken by contractor in case of defects observed in AIS type Circuit Breakers of ratings 132kV & above during the warranty period (defect liability period) shall be as per following. Further, the replaced/repaired/refurbished equipment (or part of equipment) shall have warranty in line with the GCC clause in SCC.

Sl.no.	Nature of problem	Corrective measures to be taken by contractor
1.	Blasting of interrupter, PIR, pole column,	Replacement of complete CB pole Including SF6 gas
	a. Abnormal DCRM and Travel Measurement b. Contact assembly and internal component damage, misalignment not leading to complete failure of interrupter/ PIR	Repair/replacement of affected assembly/ component based on repair procedure approved by QA
2.	Crack in insulator, cementing joint of interrupter, PIR, pole column	Replacement of affected part
3.	SF6 gas leakage from sealing and bolted joints. SF6 gas leakage detectable by any Leakage Detection Method	Rectification by replacement of gasket, O-ring, sealing, Interrupter or affected part to be replaced etc. If unable to arrest the leakage in 02 attempts, replacement of interrupter/ column
4.	SF6 gas low dew point: > (-)35 deg C at atmospheric pressure.	Re-conditioning of gas. If does not improve, complete evacuation of CB, replacement filter material and gas
5.	Oil leakage of grading capacitor Change in Capacitance value beyond +/- 5 % w.r.t. to value of Capacitance obtained at site during pre-commissioning test.	Replacement or Refurbishment of grading capacitor
6.	Pole/ break discrepancy (during O&M) Limits: Break to Break (Opening/Closing): max. 2.5 ms Phase to Phase (Opening): max. 3.33 ms Phase to Phase (Closing): max 5 ms	Rectification/replacement of affected parts
7.	Static Contact Resistance: increase >50% from factory/ pre-commissioning value or >75 micro-ohm/ break whichever is lower	Rectification/Replacement of pole
8.	Drive mechanism assembly failure	Rectification/ Replacement of affected part
9.	Trip/ close coil, density monitor, relays and contactors and components of common MB	Replacement of affected part

Note: 1) Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.

3.19 TECHNICAL SPECIFICATION FOR 220 kV & 132 kV CURRENT TRANSFORMERS (AIS)

3.19.1 SCOPE

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

3.19.2 STANDARDS

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

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

3.19.2.3 The current transformer shall comply also with the latest issue of the following Indian standard.

(i)	IS: 2705(Part-I)	Current transformers: General requirement.
(ii)	IS: 2705(Part-II)	Current transformers: Measuring Current transformers
(iii)	IS: 2705(Part-III)	Current transformers: Protective Current transformers
(iv)	IS: 2705(Part-IV)	Current transformers: Protective Current transformers for special purpose application.

3.19.3 GENERAL REQUIREMENTS

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

3.19.3.2 Current transformers shall be of Live Tank design.

3.19.3.3 The instrument transformers shall be truly hermetically sealed to completely prevent the oil inside the tank coming into contact with the outside temperature. To take care of oil volume variation the tenderer is requested to quote the current transformers with stainless steel diaphragm (bellow).

3.19.3.4 The instrument transformers shall be completely filled with oil.

3.19.3.5 A complete leak proof secondary terminal arrangement shall be provided with each instrument transformers, secondary terminal shall be brought into weather, dust and vermin proof terminal box. Secondary terminal boxes shall be provided with facilities for easy earthing, shorting, insulating and testing of secondary circuits. The terminal boxes shall be suitable for connection of control cable gland. IP rating of terminal box shall be IP 55. Spare terminals shall be provided.

3.19.3.6 All instrument transformers shall be of single-phase unit.

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

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

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

3.19.3.10 The instrument transformers shall be designed to ensure that condensation of moisture is controlled by proper selection of organic insulating materials having low moisture absorbing characteristics.

3.19.3.11 All steel work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint.

3.19.4 INSULATING OIL

The quantity of insulating oil for instrument transformers and complete specification of oil shall be stated in the tender. The insulating oil shall conform to the requirement of latest edition of IS: 335

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

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

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

- 3.19.5.3** One common marshalling box shall be supplied with each set of instrument transformers. The marshalling box shall be made of sheet steel and weather-proof. The thickness of sheet steel used shall be not less than 3.0 mm. It is intended to bring all the secondary terminals to the common marshalling. The marshalling box shall be of hot dipped galvanized steel.
- 3.19.5.4** The enclosures of the common marshalling boxes shall provide a degree of protection of not less than IP 55 (As per IS 2147).
- 3.19.5.5** The common marshalling boxes shall be provided with double hinged front doors with pad locking arrangement. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement.
- 3.19.5.6** Each marshalling box shall be fitted with terminal blocks made out of moulded non-inflammable plastic materials and having adequate number of terminals with binding screws washers etc. Secondary terminals of the instrument transformers shall be connected to the respective common marshalling boxes. All out going terminals of each instrument transformer shall terminate on the terminal blocks of the common marshalling boxes. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminals.
- 3.19.5.7** Each terminal shall be suitably marked with identification numbers. Not more than two wires shall be connected to any one terminal. At least 20 % spare terminals shall be provided over and above the required number.
- 3.19.5.8** All terminal strips shall be of isolating type terminals and they will be of minimum 10 A continuous current rating.
- 3.19.5.9** All cable entries shall be from bottom. Suitable removable gland plate shall be provided on the box for this purpose. Necessary number of cable glands shall be supplied fitted on to this gland plate. Cable glands shall be screw on type and made of brass.
- 3.19.5.10** Each common marshalling box shall be provided with two numbers of earthing terminals of galvanised bolt and nut type.
- 3.19.5.11** All steel, inside and outside work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint. The colour of finishing paint shall be as follows: -
- i) Inside: Glossy White
 - ii) Outside: Light Grey (Shade No. 697 of IS: 5)

3.19.6 BUSHINGS AND INSULATORS

- 3.19.6.1** Bushings and Insulators shall be of Porcelain, Solid core type. Porcelain used for the manufacture of bushings and insulators shall be homogeneous, free from defects, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.
- 3.19.6.2** Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. Bushings shall be designed to have sufficient mechanical strength and rigidity for the conditions under which they will be used. All bushings of identical ratings shall be interchangeable.
- 3.19.6.3** Puncture strength of bushings shall be greater than the dry flashover value. When operating at normal voltage, there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the bushings when operating at the normal rated voltage.
- 3.19.6.4** The design of bushing shall be such that the complete bushing is a self-contained unit and no audible discharge shall be detected at a voltage up to a working voltage (Phase Voltage) plus 10%. The minimum creepage distance for severely polluted atmosphere shall be 31 mm/KV.
- 3.19.6.5** Sharp contours in conducting parts should be avoided for breakdown of insulation. **The insulators shall be capable to withstand the seismic acceleration of 0.5 g in horizontal direction and 0.6g in vertical direction.**
- 3.19.6.6** Bushings shall satisfactorily withstand the insulation level specified in data sheet.
- 3.19.6.7** Rain shed/drain cover/dome shall be present in CT.
- 3.19.6.8** Bellow level indicator shall be present in CT.
- 3.19.6.9 Nitrite butyl rubber/Neoprene gaskets shall be used.**

3.19.7 TESTS

3.19.7.1 Routine/Acceptance Tests (all units)

All routine tests shall be carried out in accordance with relevant Standards. All routine/acceptance tests shall be witnessed by the Employer/his authorised representative.

3.19.7.2 Type Tests: The bidder shall furnish type test certificates and results for the all tests as per relevant Standards along with the bid for current and potential transformers of identical design.

Type test certificates so furnished shall not be older than 5 (five) years as on date of Bid opening.

QAP: QAP shall be submitted.

3.19.8 NAME PLATES

3.19.8.1 All equipment shall have non-corrosive name plates fix at a suitable position indelibly mark with full particular there on in accordance with the standard adapted. Thickness (1mm), purchase order, project name, serial no etc. shall be present in the Name plate.

3.19.9 MOUNTING STRUCTURES

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

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

3.19.10 SAFETY EARTHING

3.19.10.1 The non-current carrying metallic parts and equipment shall be connected to station earthing grid. For these two terminals suitable for 40mm X 10mm GI strip shall be provided on each equipment.

3.19.11 TERMINAL CONNECTORS (Shall be under manufacturer scope)

3.19.11.1 The equipment shall be supplied with required number of terminal connectors of approved type suitable for ACSR. The type of terminal connector, size of connector, material, and type of installation shall be approved by the Employer, as per installation requirement while approving the equipment drawings. No part of a clamp shall be less than 12mm. thick.

3.19.12 PRE-COMMISSIONING TESTS

3.19.12.1 Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Current Transformers

- (i) Insulation Resistance Test for primary and secondary.
- (ii) Polarity test.
- (iii) Ratio identification test - checking of all ratios on all cores by primary injection of current.
- (iv) Dielectric test of oil (wherever applicable).
- (v) Magnetising characteristics test.
- (vi) Tan delta and capacitance measurement
- (vii) Secondary winding resistance measurement
- (viii) Contact resistance measurement (wherever possible/accessible).

3.19.13 TECHNICAL DATA SHEET FOR CURRENT TF

3.19.13.1 For 245/145/36 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired up to the terminal blocks.

3.19.13.2 TYPE AND RATING:

All instrument transformer shall be outdoor type, single phase, oil immersed, self-cooled suitable for mounting on steel structure. The instrument transformer shall have the following ratings and particulars.

REQUIREMENTS FOR 245 KV CURRENT TRANSFORMER

No. of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age (Vk)	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	2	BUS DIFF MAIN	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	3	METERING	1600-800/1	20	0.2S	-	-	-
	4	TRANS. BACK UP	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	5	TRANS. DIFF	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap

Note:

1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869.
3. It is intended to use different ratios of the same CT at the same time for various protections and metering cores. The CTS should therefore be suitable for the above purpose by secondary tapings only. The ratio change by secondary taps is acceptable as long as the required CT specifications are achieved at all ratios.
4. The knee point voltage specified above shall be at higher ratio/ taps.
5. CT sizing calculations shall be submitted. Burden values and knee point voltage, shall be decided as per the calculations during detailed engineering.

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMER

No. of Cores	Core No.	Application	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt. voltage V _k	Max. CT sec. wdg. resistance(ohms)	Max. Excitation current at V _k (in mA)
5	1	BUS DIFF CHECK	1600-1200/1	-	PX	1600-1200/1	8/4	25 on 1600/1 Tap; 50 on 1200/1 Tap
	2	BUS DIFF MAIN	1600-1200/1	-	PX	1600-1200/1	8/4	25 on 1600/1 Tap; 50 on 1200/1 Tap
	3	METERING	1600-1200/1	20	0.2S	-	-	-
	4	TRANS. BACK UP	1600-1200/1	-	PX	1600-1200/1	8/4	25 on 1600/1 Tap; 50 on 1200/1 Tap
	5	TRANS. DIFF	1600-1200/1	-	PX	1600-1200/1	8/4	25 on 1600/1 Tap; 50 on 1200/1 Tap

Note:

1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869.
3. It is intended to use different ratios of the same CT at the same time for various protections and metering cores. The CTS should therefore be suitable for the above purpose by secondary tapings only. The ratio change by secondary taps is acceptable as long as the required CT specifications are achieved at all ratios.
4. The knee point voltage specified above shall be at higher ratio/ taps.
5. CT sizing calculations shall be submitted. Burden values and knee point voltage, shall be decided as per the calculations during detailed engineering.

MAJOR TECHNICAL PARAMETERS FOR CT

Sl. No.	Description	220kV system	132 kV system
1	Rated voltage, Um (kVrms)	245	145
2	Rated frequency (Hz)	50	50
3	No. of Poles	1	1
4	Design ambient temperature (°C)	50	50
5	Rated Primary Current (A)	1600	800/600
6	Rated extended primary current	150%	150%
7	Rated short time thermal withstand current	50kA for 3 sec	40kA for 3 sec
8	Rated dynamic current	125kAp	100kAp
9	Temperature rise over design ambient temperature	As per IEC	
10	Rated Insulation levels		
a)	Full wave impulse withstand voltage (1.2/50 microsecond)		
i)	between line terminals and ground(kVpeak)	±1050	±650
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)		
i)	between line terminals and ground(kVpeak)	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)		
i)	between line terminals and ground(kVrms)	460	275
d)	One minute power frequency withstand voltage between secondary terminals& earth (kVrms)	5kV	
11	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at (microvolts)	1000 at 156kV rms	500 at 92kV rms
12	Minimum Corona extinction voltage (kVrms)	-NA-	-NA-

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13	Seismic acceleration (Horizontal)	0.3g	0.3g
14	Partial Discharge	As per IEC	As per IEC
15	Number of terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBs.	
16	Minimum Creepage distance (mm) (31mm/kV)	7565	4495
17	System neutral earthing	Effectively Earthed	

Annexure-I: Actions required in case of defects observed during warranty period

Equipment	Nature of problem	Corrective measures to be taken by contractor
CT (Oil filled)	DGA Violation H2 > 300 ppm C2H2 > 2 ppm	CT to be refurbished or replaced
CT (Oil filled)	Violation of Tan delta Tan Delta: >0.5% (during pre-commissioning) >0.7% (in operation) or change w.r.t. to previous year value > 0.1%	Replacement of CT
CT & CVT	- Oil leakage - Low Oil level -Sec winding problem leading to open/ short circuit, saturation etc	Replacement or repair as per repair procedure approved by QA.
CVT	Secondary voltage drift: Upto ± 0.5 volts Healthy a) ± 0.5 or beyond	a) CVT to be replaced

***Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.**

3.20 TECHNICAL SPECIFICATION ACSR CONDUCTORS AND ACCESSORIES FOR CONDUCTORS

3.20.1.0 SCOPE

3.20.1.1 This Section of the Specification covers the technical parameters for design, manufacture, testing at manufacturer's works and supply of Conductor, and accessories for Power Conductors.

3.20.2.0 POWER CONDUCTOR

3.20.2.1 TYPE OF CONDUCTOR

The ACSR Conductor shall generally conform to IEC: 61089/ IS: 398 (relevant part)/ ASTM:B-232 except where otherwise specified herein.

Conductor conforming to a standard other than the Indian Standard specification then an English version of the Standard in addition to the original standard if written in a language other than English should be submitted indicating clearly the advantage, if any, that would be obtained by the Employer for adopting this standard instead of the said India Standard.

3.20.2.2 STANDARD TECHNICAL PARTICULARS

All ACSR Conductor shall satisfy all the parameters as furnished in Technical Data Sheet.

All the aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding.

The steel strands shall be hot dip galvanised and shall have a minimum zinc coating.

3.20.2.3 MATERIAL

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity and copper content as per the values indicated in the STP. They shall have the same properties and characteristics as prescribed in IEC: 60889. The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP.

The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC: 60888.

The zinc used for galvanizing shall be electrolytic High-Grade Zinc of purity. It shall conform to and satisfy all the requirements of IS:209.

3.20.2.4 JOINTS IN WIRE

In the Aluminium wires no joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.

Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand as per STP.

In the Steel wires there shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

3.20.2.5 STRANDING

The wires used in construction of a ACSR conductor shall, before and after stranding, satisfy all requirements of IS 398 with latest amendments thereof.

The lay ratio of the different layers shall be within the limits as per the said Standard. In all constructions, the successive layers shall have opposite directions of lay, the outer most layer being right-handed. The wires in each layer shall be evenly and closely stranded. In aluminium alloy stranded conductors having multiple layers of wires, the lay ratio of any layer shall not be greater than the lay ratio of the layer immediately beneath it.

3.20.2.6 TYPE/ROUTINE/ACCEPTANCE TESTS

Type Test:

The following tests shall be conducted on a sample/sample of the conductor(s) required under the package from each stranding machine from which the conductor is to be manufactured & supplied:

- a) DC resistance test on stranded conductor
- b) UTS test on stranded conductor
- c) Corona extinction voltage test (dry)
- d) Radio interference voltage test (dry)

Acceptance Test:

- a) Visual and dimensional check on drum
- b) Visual check for joints, scratches etc. and length measurement of conductor by rewinding
- c) Measurement of diameters of individual Steel and Aluminium strands
- d) Galvanizing test on steel strands
- e) Check for lay Ratios of various layers
- f) Torsion and Elongation tests on steel strands
- g) Breaking load test on steel and Aluminium strands
- h) Wrap test on Steel & Aluminium strands
- i) DC resistance test on Aluminium strands
- j) Procedure qualification test on welded joint of Aluminium strands
- k) Drum strength test (steel drum)
- l) Barrel Batten strength test (wooden drum)

The above acceptance tests shall be repeated on one conductor sample taken from site in presence of AEGCL's representative for each 500km progressive supply. The tests shall be carried out by the supplier at his cost at its own premises or any other tests centre having required facilities. The sample shall be selected by AEGCL's site representative and the tests shall be witnessed by AEGCL's representative.

Routine Tests:

- a) Check to ensure that the joints are as per Specification
- b) Check that there are no cuts, fins etc. on the strands
- c) Check that drums are as per Specification
- d) All acceptance test as mentioned above to be carried out on aluminium and steel strands of 20% of drums

Tests During manufacture:

- a) Chemical Analysis of Zinc used for galvanising
- b) Chemical Analysis of Aluminium used for making Aluminium Strands
- c) Chemical Analysis of Steel used for making Steel Strands.

3.20.2.7 REJECTION AND RETESTS

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

3.20.2.8 PACKING

All conductor reels shall conform to latest edition of IS: 1778 and be of dimensions approved by the Employer and made of seasoned wood sufficiently strong to ensure arrival at site, intact withstanding normal handling and hazards inland and ocean transit. The reels shall be of such size as to provide at least 12.5 mm clearance at all points from the conductor to the inner surface of the laggings.

All reels shall have two coats of aluminium paint on both inside and outside surface and shall be fitted with malleable iron Hub-bushings.

All reels shall be a layer of waterproof paper around the hub under the cable and another layer over the outermost layer of the cable, that is next to the lagging.

The reels shall be properly reinforced with galvanized steel wires or iron straps over the lagging in two places in an approved manner.

The wooden drums shall preferably be given protective coating of a reliable organic wood preservative before painting with Aluminium paint and the laggings shall also be given a similar treatment before being fixed on the drum. There shall be one standard length of Conductor in each drum.

3.20.2.9 TECHNICAL 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 /°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
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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 °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 /°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° C	0.1400 ohm/km
11	Ultimate tensile strength	89.67

3.21 TECHNICAL SPECIFICATION FOR SURGE ARRESTERS

3.21.1 SCOPE

3.21.1.1 This Section covers the specifications for design, manufacture, shop & laboratory testing before dispatch of 220kV, 132 kV and 33 kV 10 kA, Station class heavy duty, gapless metal (zinc) oxide Surge Arresters complete with fittings & accessories.

3.21.2 STANDARDS

3.21.2.1 The design, manufacture and performance of Surge Arresters shall comply with IS: 3070 Part-3 unless otherwise specifically specified in this Specification

3.21.3 GENERAL REQUIREMENT

3.21.3.1 The surge arrester shall draw negligible current at operating voltage and at the same time offer least resistance during the flow of surge current.

3.21.3.2 The surge arrester shall consist of non-linear resistor elements placed in series and housed in electrical grade porcelain housing/silicon polymeric of specified creepage distance.

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

3.21.3.4 The surge arrester shall be provided with line and earth terminals of suitable size. The ground side terminal of surge arrester shall be connected with 25x6 mm galvanized strip, one end connected to the surge arrester and second end to a separate ground electrode. The bidder shall also recommend the procedure which shall be followed in providing the earthing/system to the Surge Arrester.

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

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

3.21.3.7 Surge arresters shall have a suitable pressure relief system to avoid damage to the porcelain/ silicon polymeric housing and providing path for flow of rated fault currents in the event of arrester failure.

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

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

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

3.21.4 ARRESTER HOUSING

3.21.4.1 The arrester housing shall be made up of **polymer** and shall be homogenous, free from laminations, cavities and other flaws of imperfections that might affect the mechanical and dielectric quality. The housing shall be of uniform brown colour, free from blisters, burrs and other similar defects.

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

3.21.4.3 The **housing shall be so coordinated that external flashover shall not occur due to application of** any impulse or switching surge voltage up to the maximum design value for arrester. The arresters shall not fail

due to contamination. The arrester housings shall be designed for pressure relief class as given in Technical Parameters of the specification.

3.21.4.4 Sealed housings shall exhibit no measurable leakage.

3.21.5 FITTINGS & ACCESSORIES

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

3.21.5.2 The terminals shall be non-magnetic, corrosion proof, robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The top metal cap and base of surge arrester shall be galvanized. The line terminal shall have a built-in clamping device which can be adjusted for both horizontal and vertical takeoff.

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

3.21.6 SURGE MONITOR

3.21.6.1 A self-contained discharge counter suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit. Leakage current meter with suitable scale range to measure leakage current of surge arrester shall also be supplied within the same enclosure. The number of operations performed by the arrester shall be recorded by a suitable cyclometric counter and surge monitor shall be provided with an inspection window. There shall be a provision for putting ammeter to record the current/alarm contacts in the control room if the leakage current exceeds the permitted value. Similar provision shall be considered for surge counter also.

3.21.6.2 Surge monitor shall be mounted on the support structure at a suitable height so that the reading can be taken from ground level through the inspection window and length of connecting leads up to grounding point and bends are minimum.

3.21.6.3 The surge counter shall be provided with a potential free contact rated for 220/110 Volt (DC) which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to Substation Automation System/RTU.

3.21.7 TESTS

3.21.7.1 Test on Surge Arresters

The Surge Arresters offered shall be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 3070 (Part-3). In addition, the suitability of the Surge Arresters shall also be established for the following:

- i. Residual voltage test
- ii. Reference voltage test
- iii. Leakage current at M.C.O.V
- iv. P.D. test
- v. Sealing test
- vi. Thermal stability test
- vii. Aging and Energy capability test
- viii. Watt loss test
- ix. Each metal oxide block shall be tested for guaranteed specific energy capability in addition to routine/acceptance test as per IEC/IS.
- x. The surge arrester housing shall also be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 2071.

3.21.7.2 Galvanization Test

All Ferrous parts exposed to atmospheric condition shall have passed the type tests and be subjected to routine and acceptance tests in accordance with IS: 2633 & IS 6745.

3.21.8 NAME PLATE

3.21.8.1 The name plate attached to the arrester shall carry the following information:

- i. Rated Voltage
- ii. Continuous Operation Voltage
- iii. Normal discharge current
- iv. Pressure relief rated current
- v. Manufacturers Trade Mark
- vi. Name of Sub-station
- vii. Year of Manufacturer
- viii. Name of the manufacture
- ix. Purchase Order Number along with date

3.21.9 PRE-COMMISSIONING TESTS

3.21.9.1 Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval.

- (a) Operation check of LA counters.
- (b) Insulation resistance measurement.
- (c) Capacitance and Tan delta measurement of individual stacks.
- (d) Third harmonic resistive current measurement (to be conducted after energisation.)

3.21.10 TECHNICAL DATA SHEET FOR SURGE ARRESTER

Particulars	Voltage class		
	220kV	132kV	33 kV
Rated voltage of arrester, kV	198	120	30
Rated frequency, Hz	50 Hz	50 Hz	50 Hz
Nominal discharge current of arrester, kA	10	10	10
Maximum residual voltage at nominal discharge current, kV (peak)	650	395	108
Maximum steep current impulse residual voltage at kV (kVP)	730	440	120
One minute power frequency withstand voltage of arrester insulation, kV (rms)	460	275	70
1.2 / 50 μ second impulse withstand voltage of arrester insulation, kV (peak)	1050	650	170
Line discharge class	3	3	2
Insulator Housing			
Power frequency withstand test voltage(wet) (kV rms)	460	275	70
Lightning impulse withstand tests voltage(KVp)	1050	650	170
Pressure Relief Class	40	40	40
Creepage distance not less than (mm)	6125	3625	900

3.22 TECHNICAL SPECIFICATION FOR ISOLATORS

3.22.1 SCOPE

- 3.22.1.1** This section of the specification is intended to cover design specifications for manufacture and testing of 220kV/132kV and 33 kV gang operated Isolators with all fittings and accessories.
- 3.22.1.2** The Isolators are for outdoor installation suitable for horizontally mounting on mounting structures and for use at sub-stations.
- 3.22.1.3** Isolators shall be supplied with Earth Switch as and where specified.
- 3.22.1.4** The bidder shall offer ac motor operated Isolators and earth switches.

3.22.2 GENERAL

- 3.22.2.1** The Isolators and accessories shall conform in general to IS 9921 (or IEC: 62271-102) except to the extent explicitly modified in specification.
- 3.22.2.2** All isolating switches and earthing switches shall have rotating blades and pressure releasing contacts. All isolating and earth switches shall operate through 90° angle from closed position to fully open position.
- 3.22.2.3** Complete isolator with all the necessary items for successful operation shall be supplied including but not limited to the following:
- (i). Isolator assembled with complete base frame, linkages, operating mechanism, control cabinet, interlocks etc.
 - (ii). All necessary parts to provide a complete and operable isolator installation, control parts and other devices whether specifically called for herein or not.
 - (iii) The isolator shall be designed for use in the geographic and meteorological conditions as given in Section 1.

3.22.3 DUTY REQUIREMENTS

- 3.22.3.1** Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.
- 3.22.3.2** The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical and mechanical interlocks provided in the operating mechanism.
- 3.22.3.3** In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of failsafe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated elsewhere in this specification.
- 3.22.3.4** The earthing switches shall be capable of discharging trapped charges of the associated lines.
- 3.22.3.5** The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation.
- 3.22.3.6** The isolator shall be capable of making/breaking magnetizing current of 0.7A at 0.15 power factor and capacitive current of 0.7A at 0.15 power factor at rated voltage.

3.22.4 CONSTRUCTIONAL DETAILS

3.22.4.1 All isolating switches and earthing switches shall have rotating blades and pressure releasing contacts. All isolating and earth switches shall operate through 90° angle from closed position to fully open position.

3.22.5 Contacts:

3.22.5.1 The contacts shall be self-aligning and self-cleaning and so designed that binding cannot occur after remaining closed for prolonged periods of time in a heavily polluted atmosphere.

3.22.5.2 No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

3.22.5.3 Contact springs shall not carry any current and shall not lose their characteristics due to heating effects.

3.22.5.4 The moving contact of double break isolator shall have turn-and -twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

3.22.6 Blades:

3.22.6.1 All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts, shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. All ferrous castings except current carrying parts shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

3.22.6.2 The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable adequate corona shield shall be provided. Corona shields/rings etc., shall be made up of aluminium/aluminium alloy.

3.22.6.3 Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

3.22.6.4 The switch shall be designed such that no lubrication of any part is required except at very infrequent intervals i.e., after every 1000 operations or after 5 years whichever is earlier.

3.22.7 Insulators:

3.22.7.1 The insulator shall conform to IS: 2544 and/or IEC-60168. The insulators shall have a minimum cantilever strength of 600/400 Kgs. for 145/33 kV insulators respectively.

3.22.7.2 Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

3.22.8 Base:

Each isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a supporting structure.

3.22.9 EARTHING SWITCHES

3.22.9.1 Where earthing switches are specified, these shall include the complete operating mechanism and auxiliary contacts.

3.22.9.2 The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

3.22.9.3 The earthing switches shall be constructionally interlocked with the isolator so that the earthing switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks.

3.22.9.4 Suitable mechanical arrangement shall be provided for de-linking electrical drive for mechanical operation.

3.22.9.5 Each earth switch shall be provided with flexible copper/aluminium braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

3.22.9.6 The frame of each isolator and earthing switches shall be provided with two reliable earth terminals for connection to the earth mat.

3.22.9.7 Isolator design shall be such as to permit addition of earth switches at a future date. It should be possible to interchange position of earth switch to either side.

3.22.9.8 The earth switch should be able to carry the same fault current as the main blades of the Isolators and shall withstand dynamic stresses.

3.22.10 OPERATING MECHANISM

3.22.10.1 The bidder shall offer **motor operated** Isolators and earth switches. Earth Switches of 36 kV shall only be motor operated.

3.22.10.2 Control cabinet/operating mechanism box shall be made of aluminium sheet of adequate thickness (minimum 3 mm).

3.22.10.3 A "Local/Remote" selector switch and a set of open/ close push buttons shall be provided on the control cabinet of the isolator to permit its operation through local or remote push buttons.

3.22.10.4 Provision shall be made in the control cabinet to disconnect power supply to prevent local/remote power operation.

3.22.10.5 Suitable reduction gearing shall be provided between the motor and the drive shaft of the isolator. The mechanism shall stop immediately when motor supply is switched off. If necessary, a quick electromechanical brake shall be fitted on the higher speed shaft to effect rapid braking.

3.22.10.6 Manual operation facility (with handle) should be provided with necessary interlock to disconnect motor.

3.22.10.7 Gear should be of forged material suitably chosen to avoid bending/jamming on operation after a prolonged period of non-operation. Also, all gear and connected material should be so chosen/surface treated to avoid rusting.

3.22.11 OPERATION

3.22.11.1 The main Isolator and earth switches shall be gang operated.

3.22.11.2 The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments, by means of screw thread which can be locked with a lock nut after an adjustment has been made. The isolator and earth switches shall be provided with "over center" device in the operating mechanism to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

3.22.11.3 Each isolator and earth switch shall be provided with a manual operating handle enabling one man to open or close the isolator with ease in one movement while standing at ground level. Detachable type manual operating handle shall be provided. Suitable provision shall be made inside the operating

mechanism box for parking the detached handles. The provision of manual operation shall be located at a height of 1000 mm from the base of isolator support structure.

- 3.22.11.4** The isolator shall be provided with positive continuous control throughout the entire cycle of operation. The operating pipes and rods shall be sufficiently rigid to maintain positive control under the most adverse conditions and when operated in tension or compression for isolator closing. They shall also be capable of withstanding all torsional and bending stresses due to operation of the isolator. Wherever supported the operating rods shall be provided with bearings on either ends. The operating rods/ pipes shall be provided with suitable universal couplings to account for any angular misalignment.
- 3.22.11.5** All rotating parts shall be provided with grease packed roller or ball bearings in sealed housings designed to prevent the ingress of moisture, dirt or other foreign matter. Bearings pressure shall be kept low to ensure long life and ease of operation. Locking pins wherever used shall be rustproof.
- 3.22.11.6** Signaling of closed position shall not take place unless it is certain that the movable contacts, have reached a position in which rated normal current, peak withstand current and short time withstand current can be carried safely. Signaling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is at least 80% of the isolating distance.
- 3.22.11.7** The position of movable contact system (main blades) of each of the Isolators and earthing switches shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the Isolators and earthing switch. The indicator shall be of metal and shall be visible from operating level.
- 3.22.11.8** The Supplier shall furnish the following details along with quality norms, during detailed engineering stage.
- (i) Current transfer arrangement from main blades of isolator along with milli volt drop immediately across transfer point.
 - (ii) Details to demonstrate smooth transfer of rotary motion from motor shaft to the insulator along with stoppers to prevent over travel.

3.22.12 TEST AND INSPECTION

3.22.12.1 The switches shall be subjected to the following type test in accordance to with IS: 9920.

- i. Dielectric test (impulse and one minute) power frequency withstands voltage.
- ii. Temperature rise test
- iii. Rated off load breaking current capacity
- iv. Rated active load breaking capacity
- v. Rated line charging breaking capacity
- vi. Rated short time current
- vii. Rated peak withstand current
- viii. Mechanical and Electrical Endurance

3.22.12.2 The equipment shall be subjected to the following routine test.

- (i) Power frequency voltage dry test
- (ii) Measurement of resistance of the main circuit
- (iii) Operating test.

3.22.12.3 The porcelain will have pull out test for embedded component and beam strength of porcelain base.

3.22.13 AUXILIARY SWITCHES

3.22.13.1 All isolators and earth switches shall be provided with 220/110 volts, 6 Ampere auxiliary switches for their remote position indication on the control board and for electrical interlocking with other equipment. In addition to the auxiliary switches required for remote position indications and for their operation. There shall be six pairs of NO and six pairs of NC contacts for each isolating switch and three pairs of NO and three pairs of NC contacts for each earthing switch. All contacts shall be brought out to terminal blocks

3.22.14 CONNECTORS

3.22.14.1 Each isolator shall be provided with appropriate number of bimetallic clamping type connectors as detailed in the schedule of requirement. The maximum length of jumper that may be safely connected or any special instruction considered necessary to avoid under loads on the post isolators should be stated by the bidder.

3.22.15 MOUNTING STRUCTURES

3.22.15.1 All isolators and earthing switches shall be rigidly mounted in an upright position on their own supporting structures. Details of the supporting structures shall be furnished by the successful tenderer. The isolators should have requisite fixing details ready for mounting them on structures.

3.22.16 PRE-COMMISSIONING TESTS

Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

- i. Insulation resistance of each pole.
- ii. Manual and electrical operation and interlocks.
- iii. Insulation resistance of control circuits and motors.
- iv. Ground connections.
- v. Contact resistance.
- vi. Proper alignment so as to minimise to the extreme possible the vibration during operation.
- vii. Measurement of operating Torque for isolator and Earth switch.
- viii. Resistance of operating and interlocks coils.
- ix. Functional check of the control schematic and electrical & mechanical interlocks.
- x. 50 operations test on isolator and earth switch.

3.22.17 TECHNICAL DATA SHEET FOR ISOLATORS

No.	Technical Particulars	Isolators class		
		220 kV	132 kV	33 kV
1	Nominal system voltage, kV	220	132	33
2	Highest system voltage, kV	245	145	36
3	Rated frequency, Hz.	50	50	50
4.	Type of Isolator	Single Centre Break	Single Centre Break	Double Break, centre pole rotating
5	Rated continuous current, A	3150	2000	1250
6	Rated short time current, kA	50	40	25
7	Rated duration of short time current, (second)	3	3	1
8	Rated lightning impulse withstand voltage, kV (peak)			
	i) To earth & between poles	1050	650	170
	ii) Across isolating distance	1220	750	195
9	Rated 1 minute power frequency withstand voltage, kV (rms)			
	i) To earth & between poles	315	275	70
	ii) Across isolating distance	530	460	80
10	Minimum Creepage distance of insulators, mm	7595	4495	900
11	Temperature rise	As per relevant IEC 62271 -102/ IS 9921		

3.23 TECHNICAL SPECIFICATION FOR POWER & CONTROL CABLES

3.23.1.0 GENERAL REQUIREMENT

- 3.23.1.1 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.
- 3.23.1.2 For all control/protection/instrumentation purposes PVC insulated armoured control cables of minimum 2.5 sq. mm Size with stranded Copper conductors shall be used.
- 3.23.1.3 While preparing cable schedules for control/protection purpose following shall be ensured:
- i. Separate cables shall be used for AC & DC.
 - ii. For different cores of CT & PT separate cable shall be used.
 - iii. At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.
- 3.23.1.4 For control cabling, including CT/VT circuits, 2.5 sq.mm size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration additional cores shall be used. Further, for potential circuits of energy meters separate connections by 2 cores of 2.5sq.mm size shall be provided.
- 3.23.1.5 Standard technical data sheets for cable sizes up to and including 1100V are enclosed at Clause 3.23.3. Cable sizes shall be offered /manufactured in accordance with parameters specified in standard technical data sheets. Technical data sheet for any other cores/sizes required during detailed engineering shall be separately offered for Employer's approval by the contractor/supplier.

3.23.2.0 TECHNICAL REQUIREMENTS

3.23.2.1 General

- 3.23.2.1.1 The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water.
- 3.23.2.1.2 The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.
- 3.23.2.1.3 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables, armours shall be of H4 grade Aluminium.
- 3.23.2.1.4 The fillers and inner sheath shall be of non-hygroscopic, fire-retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.
- 3.23.2.1.5 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.
- 3.23.2.1.6 Strip wire armouring method shall not be accepted for any of the cables. For control, cables only round wire armouring shall be used.

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

3.23.2.1.8 All the cables shall pass fire resistance test as per IS:1554 (Part-I)

3.23.2.1.9 The normal current rating of all PVC insulated cables shall be as per IS:3961.

3.23.2.1.10 Repaired cables shall not be accepted.

3.23.2.1.11 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

3.23.2.2 XLPE Power Cables

The XLPE (90°C) insulated cables shall be of FR type, C1 category conforming to IS: 7098 (Part-I) and its amendments read along with this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted. In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC of type ST-2 of IS: 5831. When armouring is specified for single core cables, the same shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC of Type ST-2 of IS: 5831 for all XLPE cables.

3.23.2.3 PVC Power Cables

3.23.2.3.1 The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part- I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multicore cables. For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS 5831 for all cables.

3.23.2.4 PVC Control Cables

3.23.2.4.1 The PVC (70°C) insulated control cables shall be of FR type C1 category conforming to IS: 1554 (Part- 1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour.

3.23.2.4.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS 1554 (Part-1).

3.23.3 DATA SHEET FOR CABLES

1. Power Cables

Sl. No.	Description	3 ½ C 300mm ²	Other Power Cables	
			70 mm ² , 35 mm ² , 25mm ² , 16 mm ²	6 mm ² & 4mm ²
1	Applicable Standard	IS: 7098/PT-I & its referred standards	IS: 1554/PT-I& its referred standards	
2	Type Designation	A2XWY	AYFY	AYWY
3	Rated Voltage(volts)	1100	1100	1100
4	Type & Category	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	Suitable for both		
6	Conductor			
	a) Material	Stranded Aluminium as per IS : 8130		
	b) Grade	H 2 (Electrolytic grade)		
	c) Number of wires(No.)	As per IS 8130		
	d) Form of Conductor	Stranded compacted circular/sector shaped	Stranded compacted circular/sector shaped	Non-compactd Stranded circular
	e) Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layers		
7	Insulation			
	a) Composition of insulation	Extruded XLPE as per IS-7098 Part(1)	Extruded PVC type A as per IS-5831	Extruded PVC type A as per IS-5831
	b) Thickness of insulation(mm)	As per applicable Standard		
8	Inner Sheath material	Extruded PVC type ST-2 as per IS-5831	Extruded PVC type ST-1 as per IS- 5831	
9	Type and material of armour	Gal. Steel wire	Gal. Steel Strip	Gal. Steel wire
10	Outer Sheath (PVC)	ST-1 & FR	ST-2 & FR	ST-2 & FR
11	Overall diameter of cable	As per applicable Standard		

2. Control Cables

Sl. No.	Description	Particulars
1	Applicable Standard	IS: 1554/PT-I & its referred standards
2	Type Designation	YWY
3	Rated Voltage(volts)	1100
4	Type & Category	FR & C1
5	Suitable for earthed or unearthed system	Suitable for both
6	Conductor	
	a) Material	Plain annealed High Conductivity stranded Copper (as per IS 8130)
	b) Grade	Electrolytic
	c) Number of wires(No.)	As per IS 8130
	d) Form of Conductor	Non-compacted Stranded circular
	e) Direction of lay of stranded layers	Outermost layer shall be R.H lay
7	Insulation	
	a) Composition of insulation	Extruded PVC type A as per IS-5831
	b) Thickness of insulation(mm)	As per applicable Standard
8	Inner Sheath material	Extruded PVC type ST-1 as per IS-5831
9	Type and material of armour	Gal. Steel wire
10	Outer Sheath (PVC)	ST-1 & FR
11	Overall diameter of cable	As per applicable Standard
12	No. of Cores	As per Bill of Materials

3.24 TECHNICAL SPECIFICATION FOR CONSTRUCTION WORKS IN SUBSTATIONS

3.24.1.0 GENERAL

3.24.1.1 The intent of this Section of the Specification is to cover requirements which are to be followed in construction of switchyards including civil works in the switchyard. Irrespective of whether mentioned or not all the equipment shall be supplied at site, erected, tested and commissioned. The prices quoted in the Price Schedule are deemed to include for these activities.

3.24.1.2 The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the Employer based on Drawings supplied to the Contractor by the Employer with this specification. For all structures, foundations, etc., necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance based on the input provided (drawings and design parameters) by the Employer in this Technical Specification. Certain minimum requirements are indicated in this Section for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

3.24.1.3 A set of drawings are enclosed for reference of the Bidder. The drawings shall be treated as for bidding purpose only.

3.24.1.4 The contractor shall maintain the overall dimensions of the substation, buildings, bay length, bay width, phase to earth clearance, phase to phase clearance, ground clearances, sectional clearances, clearances between buses and bus heights but may alter the spacing between equipment based on actual dimensions equipment offered to obtain the statutory electrical clearances required for the substation and to suite the physical requirements of available land for the substation etc.

3.24.1.5 The enclosed drawings give the basic scheme, layout of substation, associated services etc. in case of any discrepancy between the drawings and text of specification, the requirements of text shall prevail in general. However, the Contractor is advised to get these clarified from Employer.

3.24.2.0 Surface Preparation and Stone Spreading

3.24.2.1 The switchyard works of the above substations under the scope of this bid shall be carried out in the existing vacant bays with earthing system already in place. It is responsibility of the Contractor to earth all the newly erected equipment and structures by connecting to the existing earth mat. It is also in the scope of Contractor to clean, level and spreading of gravels after installation of new equipment and structures in these bays.

3.24.2.2 A surface course of minimum 100 mm thickness of 20 mm nominal size river pebbles or (single size ungraded) broken stone shall be spread.

3.24.3.0 Transformer Foundation and Oil Recovery System

3.24.3.1 The Contractor shall provide an oil recovery system for all power transformers containing insulating oil, integrated with the transformer foundations.

3.24.3.2 The oil recovery system shall be provided in order to avoid spread of fire by the oil, and for environmental protection.

Each transformer including oil conservator tank and cooler banks, etc., shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall from the transformer shall be 20% of the transformer height or 0.8 m whichever is more. The oil collection pit thus formed shall have a void volume equal to 125% volume of total oil in the transformer.

The grating shall be made of Galvanised MS flat of size 40 mm x 5 mm placed at 30 mm center to center and 25 mm x 5 mm GI MS flat at a spacing of 150 mm at right angle to each other. Maximum length of grating shall be 2000 mm and width shall not be more than 500 mm. The gratings, supported on Galvanised ISMB 150 mm, shall be placed at

the formation level and will be covered with 100 mm thick layer of broken/crushed/non-crushed stone having size 35 mm to 45 mm.

Each oil collection pit shall be drained towards a sump pit within the collection whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry and clean.

3.24.3.3 The retaining walls which make up the oil collection pit shall be made of fire-resistant material such as reinforced cement concrete, fire brick etc., and shall be impervious to oil.

The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside.

The bottom of the pit shall have a uniform slope towards the sump pit.

3.24.3.4 Drainage

A device showing level of sump pit shall be provided by Contractor, fitted along with the automatic/manual pumping system, which shall have sufficient capacity to evacuate the rainwater from the sump pit. The Contractor may propose another better scheme, if agreed by Employer.

If the heights of the retaining walls, which form the oil collection pit, exceed 60 cm, steps shall be provided to facilitate access to the oil collection pit.

When designing the oil collection pit, the movement of the transformer must be taken into account.

3.24.3.5 Transformers shall be mounted on a rail fitted on top of the foundation for its easy removal from foundation/oil collection pit.

3.24.4.0 Cable Trenches and Cable Trays

3.24.4.1 Design and construction of cable trenches with pre-cast removal R.C.C cover (with lifting arrangement) as per drawing enclosed with the Bid Documents shall be carried out by the Contractor.

3.24.4.2 Cable Trays

(i). The cable trays shall be of G.S. sheet and minimum thickness of sheet shall be 2mm.

(ii). Finished Cable Trays shall have a standard width of 300 mm.

(iii). The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards. Contractor shall have to demonstrate all tests as per specification and equipment shall comply with all requirements of the specification.

a) Test for galvanising (Acceptance Test)

The test shall be done as per approved standards.

b) Deflection Test: (Type Test)

A 2.5 metre straight section of 300mm, wide cable tray shall be simply supported at two ends. A uniform distributed load of 76 kg/m shall be applied along the length of the tray. The maximum deflection at the mid-span shall not exceed 7mm.

3.24.4.3 The Contractor shall provide embedded steel plates of adequate size on the walls of concrete cable trench for supports for cable trays. Insert plates will be provided at an interval of 2000 mm.

3.24.4.4 The cable trench walls shall be designed for following loads: -

(a) Dead load of 155 kg/M length of cable support (tray) + 75 kg on one tier at the end.

(b) Triangular earth pressure + uniform surcharge pressure of 2T/m².

3.24.4.5 RCC cable trench cover shall be designed for self-weight of slab + UDL of 2000 kg/m² + a concentrated load of 200 kg at center of span on each slab panel.

3.24.4.6 Cable trench inside the Control Room shall be covered with 6 mm thick chequered plates with lifting arrangement.

3.24.4.7 Cable trench crossing the road/rails shall be designed for class AA. Loading of IRC/relevant IS Code and should be checked for transformer loading.

3.24.4.8 Trenches shall be drained. Necessary sumps be constructed and sump pumps, if necessary, shall be supplied. Cable trenches shall not be used as storm water drains.

3.24.4.9 The top of trenches shall be kept at least 100 mm above the finished ground level. The top of cable trench shall be such that the surface rainwater does not enter the trench.

3.24.4.10 All metal parts inside the trench shall be connected to the earthing system.

3.24.4.11 Cables from trench to equipment shall run in hard conduit pipes.

3.24.4.12 Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.

3.24.4.13 The trench bed shall have a slope of 1/500 along the run and 1/250 perpendicular to the run.

3.24.4.14 All the construction joints of cable trenches i.e., between base slab to base slab and the junction of vertical wall to base slab as well as from vertical wall to wall and all the expansion joints shall be provided with approved quality PVC water stops of approx. 230 x 5 mm size for those sections where the ground water table is expected to rise above the junction of base slab and vertical wall of cable trenches.

3.24.4.15 Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12 mm thick 1:6 cement sand mortar.

3.24.5.0 Foundation and RCC Construction

3.24.5.1 General

3.24.5.1.1. Work covered under this Clause of the Specification comprises the design and construction of foundations and other RCC constructions for switchyard structures, equipment supports, trenches, drains, jacking pad, control cubicles, bus supports, transformer, marshalling kiosks, auxiliary equipment and systems, buildings, tanks, boundary wall or for any other equipment or service and any other foundation required to complete the work.

3.24.5.1.2. Concrete shall conform to the requirements mentioned in IS: 456 and all the tests shall be conducted as per relevant Indian Standard Codes as mentioned in Standard field quality plan appended with the specification.

A minimum grade of M15 concrete (1:2:4 mix) shall be used for all structural/load bearing members as per latest IS 456.

3.24.5.1.3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.

3.24.5.1.4. The switchyard foundation's plinths and building plinths shall be minimum 300 mm and 500 mm above finished ground level respectively.

3.24.5.1.5. Minimum 75 mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches, etc., to provide a base for construction.

3.24.5.1.6. Concrete made with Portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.

3.24.5.1.7. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof.

The Spread footings foundation or pile foundation as may be required based on soil/subsoil conditions and superimposed loads shall be provided.

3.24.5.1.8. If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre cast or under reamed type as per relevant parts of IS Code 2911. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests from the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

3.24.5.2 Design

3.24.5.2.1. All foundation shall be of reinforced cement concrete. The design and construction of RCC structures shall be carried out as per IS: 456 and minimum grade of concrete shall be M-15. Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the Employer.

3.24.5.2.2. Limit state method of design shall be adopted unless specified otherwise in the specification.

3.24.5.2.3. For detailing of reinforcement IS: 2502 and SP: 34 shall be followed. Cold twisted deformed bars (Fe-415 N/mm²) conforming to IS: 1786 shall be used as reinforcement. However, in specific areas, mild steel (Grade-I) conforming to IS: 432 can also be used. Two layers of reinforcement (on inner and outer face) shall be provided for wall and slab sections having thickness of 150 mm and above. Clear cover to reinforcement towards the earth face shall be minimum 40 mm.

3.24.5.2.4. RCC water retaining structures like storage tanks, etc., shall be designed as uncracked section in accordance with IS: 3370 (Part I to IV) by working stress method. However, water channels shall be designed as cracked section with limited steel stresses as per IS:3370 (Part I to IV) by working stress method.

3.24.5.2.5. The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and or superstructure and other conditions, which produces the maximum stresses in the foundation or the foundation component and as per the relevant IS Codes of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.

3.24.5.2.6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

3.24.5.2.7. Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/harmful to the concrete foundations.

3.24.5.2.8. RCC columns shall be provided with rigid connection at the base.

3.24.5.2.9. All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant IS Codes or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.

3.24.5.2.10. Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of sub-structures of any underground enclosures, earth pressure at rest shall be considered.

3.24.5.2.11. In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq.m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, sub-structure of any underground hollow enclosure, etc., for the vehicular traffic in the vicinity of the structure.

3.24.5.2.12. Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:

- a) Full water pressure from inside and no earth pressure and ground water pressure and surcharge pressure from outside (application only to structures, which are liable to be filled up with water or any other liquid).
- b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
- c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.

3.24.5.2.13. The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.

3.24.5.2.14. The foundations of transformer and circuit breaker shall be of block type foundation. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

3.24.5.2.15. The tower and equipment foundations shall be checked for a factor of safety of 2.0 for normal condition and 1.50 for short circuit condition against sliding, overturning and pullout. The same factors shall be used as partial safety factor overloads in limit state design also.

3.24.5.3 Admixtures & Additives

3.24.5.3.1 Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.

3.24.5.3.2 Admixtures in concrete shall conform to IS: 9103. The water proofing cement additives shall conform to IS: 2645. Employer shall approve concrete Admixtures/Additives.

3.24.5.3.3 The Contractor may propose and the Employer may approve the use of a water-reducing retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.

3.24.5.3.4 The water reducing set-retarding admixture shall be an approved brand of Ligno sulphonate type admixture.

3.24.5.3.5 The water proofing cement additives shall be used as required/advised by the Employer.

3.24.6.0 Bus Bars and Bus Bar Supports

3.24.6.1.1 The bus bars shall be outdoor strung bus bars with ACSR conductor supported on lattice.

3.24.6.1.2 If asked for, the substation steel structures shall be designed as per Section-3 of this specification.

3.24.7.0 ACSR Conductors

3.24.7.1 The Conductor shall conform to IS: 398 (latest edition) except where otherwise specified herein.

3.24.7.2 The details of the ACSR Moose, ACSR Zebra and ACSR Panther conductors are tabulated below:

Sl. No.	DESCRIPTION	ACSR 'MOOSE'	ACSR 'ZEBRA'	ACSR 'PANTHER'
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Supply, ETC and Associated Works for Augmentation of 2x100 MVA, 220/132 KV Rangia GSS By 2x200 MVA Auto-Transformer (Phase-II)

1	Code name	MOOSE	ZEBRA	PANTHER
2	Number of strands & size	Al: 54/ 3.53 mm	Al: 54/ 3.18 mm	Al: 30/ 3.00 mm
		St: 7/ 3.53 mm	St: 7/ 3.18 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	$23 \times 10^{-6} / ^\circ\text{C}$	$19.35 \times 10^{-6} / ^\circ\text{C}$	$19.35 \times 10^{-6} / ^\circ\text{C}$
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 mm ²	428.90 mm ²	212.10 mm ²
9	Total sectional area	597.00 mm ²	484.50 mm ²	261.50 mm ²
10	Calculated D.C. resistance at 20° C	0.05552 ohm/km	0.06869 ohm/km	0.1400 ohm/km
11	Ultimate tensile strength	161.2 kN	130.32 kN	89.67

3.24.8.0 Electrical Clearances

3.24.8.1 Following minimum electrical clearances (outdoor) shall be maintained in the switchyard:

Sl. No.	Clearance	220 KV	132 kV	33 KV
1	Phase to Phase	2400 mm	1300 mm	320 mm
2	Phase to Earth	2400 mm	1300 mm	320 mm
3	Sectional Clearance	5000 mm	4000 mm	2800 mm
4	Live part to ground	5500 mm	4600 mm	3700 mm
5	Base of insulator (supporting live part) to ground	2500 mm	2500 mm	2500 mm

3.24.9.0 Earthing System

3.24.9.1 The earthing system in the existing substations is consists of MS/GI flats laid in mesh at a depth of 0.75 meter to 1.0 meter with combination of electrodes. This existing earthing system shall be extended to the extended portion of the switch yard by laying GI flats of size 50x10 mm (or as specified in the Bill of Materials) covering the entire extended switchyard area and earth electrodes of cast iron pipes distributed all over the mesh. The earth electrodes shall also be placed all around the periphery of the mesh at regular intervals.

3.24.9.2 General

3.24.9.2.1 GI flats of size 25 mm X 6 mm shall be used for all risers.

3.24.9.2.2. The earth mat shall be created by laying the earthing conductor (GI MS flats) in both directions perpendicularly. The mesh points so created and all other joints shall be welded and painted and painted with rust proof paint after welding.

3.24.9.2.3. The extension of earth mat shall be made by laying the GI flats at a distance of 4.0 meter in both directions perpendicularly and at the same depth of existing earth mat. The mesh points so created and all other joints shall be welded and painted and painted with rust proof paint after welding.

3.24.9.2.4. The all-earth electrodes and risers for equipment and other earthing must be connected at mesh points of the earth mat. All such connections shall be welded.

3.24.9.2.5. All metallic supporting structures and non-current carrying metallic parts of all equipment shall be provided with double earthing.

3.24.9.2.6. All LAs, and all transformer neutrals must be earthed through separate earth electrodes and in turn these electrodes shall be connected to the main earth grid.

3.24.9.2.7. All metallic parts in cable trenches shall also be connected to the earth mat.

3.24.9.2.8. The extended switchyard area shall be covered with gravel or crushed rocks to a thickness of 150 mm. This covering should cover entire switchyard area and also extend beyond the periphery of the earth mat to an extent of at least 1 meter.

3.24.9.3 Summary of Earthing System

Sl. No.	Item	Size	Materials
1.	Main Earthing Conductor to be buried in ground	50mm x 10 mm	GI Flat
2.	Conductor above ground & earthing leads (for equipment)	50mm x 10 mm	GI Flat
3.	Conductor above ground & earthing leads (for columns & aux. structures)	50mm x 10 mm	GI Flat
4.	Earthing of indoor LT panels, Control panels and outdoor marshalling boxes, MOM boxes, Junction boxes & Lighting Panels etc.	50mm x 10 mm	GI Flat
5.	Rod Earth Electrode	40mm dia, 3000 mm long	Mild Steel
6.	Pipe Earth Electrode (in treated earth pit) as per IS 3043	40mm dia, 3000 mm long	Galvanised Steel

3.24.10.0 Protection Against Direct Lightning

3.24.10.1 Protection against direct lightning shall be provided by stringing 7/3.66 mm G.I. wires conforming to IS 2141.

3.24.10.2 G.I. wires for shielding shall conforming to IS 2141. Parameters of galvanised steel wires shall be as follows:

- a) No of Strand: 7
- b) Diameter of single strand: 3.66 mm
- c) Minimum Breaking Load: 6970 KG
- d) Overall Diameter: 10.98 mm
- e) Area: 72.25 mm²

3.24.11.0 Bay Marshalling Kiosks

3.24.11.1 One number of bay marshalling kiosk shall be provided for each 220 kV and 132 kV bay and one number kiosk shall be provided for each two numbers of 33 kV bays under present scope. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose: -

- i) To receive two incoming 415V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and distribute minimum four outgoing 415V, 3 phase, 16 Amps AC supplies controlled by MCB.
- ii) To distribute minimum six outgoing 240V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.

3.24.12.0 Insulator and Hardware Fittings

3.24.12.1 General

- a) The Contractor shall supply insulators of suspension, tension and post type as required complete with all necessary hardware and accessories, including fittings for fixing insulators to steel structures as required.
- b) The porcelain shall be sound, free from defects, thoroughly vitrified and smoothly glazed.
- c) Unless otherwise specified, the glaze shall be brown colour. The glaze shall cover all the porcelain parts of the insulators except those areas which serve as support during firing or are left unglazed for purpose of assembly.
- d) The design of the insulator shall be such that stress due to expansion and contraction in any part of the insulator shall not lead to deterioration. The porcelain shall not engage directly with hard metal.
- e) Cement use in the construction of insulator shall not cause fracture by expansion or loosening by contraction and proper care shall be taken to locate the individual parts correctly during cementing. The cement shall not give rise to chemical reaction with metal fitting and its thickness shall be as uniform as possible.
- f) Pins and caps shall be made of drop forged steel, duly hot dip galvanized as per IS 2629. These shall not be made by jointing, welding, shrink fitting or any other process.
- g) Security clips/split pins shall be made of good quality of stainless steel.
- h) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings.
- i) Post type insulators shall be of long rod type or solid core type and preferably of single piece type for all voltage classes. These shall be complete with necessary fittings to hold Aluminium tubes or ACSR conductor as required.
- j) The items of hardware and fittings shall make complete assemblies which are necessary for their satisfactory performance. Such parts shall be deemed to be within the scope of this specification.

3.24.12.2 Disc Insulator Strings

Each insulator string shall consist of following numbers of Disc Insulator Units & parameters.

Sl. No.	Type of string	No of Disc Insulator Unit for		
		220 kV	132 kV	33 kV
1	Suspension	14	9	3
2	Tension	15	10	4

3.24.12.3 Parameters

3.24.12.3.1 Disc Insulators

- | | |
|---|--|
| a) Type | : Ball and Socket |
| b) Colour | : Brown |
| c) Surface | : Glazed |
| d) Locking Device | : W or R type security clip |
| e) Size of Disc | : 255 mm x 145 mm |
| f) Size of Pin Ball | : 16 mm |
| g) Creepage Distance (Min) | : 320 mm |
| h) Electro mechanical Strength | : 70 KN |
| i) Power frequency withstand test voltage | : 75 KV Dry, 45 KV Wet |
| j) Minimum dry Impulse withstand | : 125 KV peak Test voltage (+/- wave) |
| k) Puncture Voltage | : 1.3 X actual dry flash over voltage. |

3.24.12.3.2. Post Insulators

Sl. No.	Parameters	220 kV	132 kV	33 kV
1	Highest system voltage	245 kV	145 kV	36 kV
2	Dry one minute power frequency test Voltage	510 kV	275 kV	75 kV
3	Wet one minute power frequency test Voltage	460 kV	275 kV	75 kV
4	Impulse voltage withstand test	1050 kV	650 kV	170 kV
5	Minimum Creepage Distance	6125 mm	3625 mm	900 mm
6	Minimum Bending Strength (upright)	6 kN	4 kN	3 kN

3.24.13.0 Clamps, Connectors and Spacers

3.24.13.1 Clamps and connectors shall conform to IS 2121 unless otherwise mentioned hereunder.

3.24.13.2 Clamps and connectors shall be made of materials listed below: -

- (i) For connecting ACSR: Aluminium alloy casting conforming to designation A6 of IS 617.
- (ii) For connecting equipment: Bimetallic connectors made from aluminium alloy terminals made of copper casting conforming to designation A 6 of IS 617.
- (iii) For connecting GI Shield wire: Malleable iron casting.
- (iv) Expansion Connectors: Copper lamination to grade FRTP-2 of IS 191.
- (v) Bolts, nuts, plain washers: Hot dip galvanised mild steel and spring washers for items (i), (ii) and (iii).

3.24.13.3 Spacers

Spacers shall conform to IS 10162. Spacers for bundle conductors (where specified) shall be provided at but not limited to the following locations:

- (i) At intervals not exceeding 2.5 meters in case of strung bus bars or other bundled strung conductors.
- (ii) At one meter interval in case of jumper connections.

No magnetic material shall be used in fabrication of spacers except for the GI bolts and nuts.

3.24.13.4 T Clamp and Equipment Clamps

a) T Clamps:

- i. Standard Specification and tests shall be as per IS:5561.
- ii. For connecting ACSR conductor aluminium alloy casting conforming to designation A 6 of IS 617.
- iii. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electrogalvanized.
- iv. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.
- v. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.
- vi. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.
- vii. No part of a clamp shall be less than 12 mm thick for fittings suitable up to size of ACSR Panther conductor, no part of a clamp shall be less than 15 mm thick for fittings suitable for ACSR Zebra conductor and ACSR Moose conductor.
- viii. All sharp edges and corners shall be blurred and rounded off.
- ix. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.
- x. From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.

b) Equipment Clamps (CB, ISOLATOR, CT and PI):

- i. Standard Specification and tests shall be as per IS:5561.
- ii. For connecting ACSR conductor aluminium alloy casting conforming to designation A 6 of IS 617.
- iii. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electrogalvanized.
- iv. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.
- v. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.
- vi. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.
- vii. No part of a clamp shall be less than 12 mm thick for fittings suitable up to size of ACSR Panther conductor, no part of a clamp shall be less than 15 mm thick for fittings suitable for ACSR Zebra conductor and ACSR Moose conductor.
- viii. All sharp edges and corners shall be blurred and rounded off.
- ix. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.
- x. From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.

3.24.14.0 Supply of Construction Materials by The Contractor

3.24.14.1 The contractor has to make his own arrangements for procurement, supply and use of construction materials like cement, M.S. rounds, H.B.G. metal and sand.

3.24.14.2 Cement

The contractor has to make his own arrangements for the procurement of cement to required specifications required for the work subjected to the follows:

- a) The contractor shall procure cement (approved BSI marked of OPC or PPC), required for the work only 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 weighing of random sample from the available stock and shall conform with the specification laid down by the Indian Standard Institution or other standard foreign institutions laid down by the Indian Standard Institution or other standard foreign institutions as the case may be. Cement shall be got tested for all the tests as directed by Engineer-in-Charge at least one month in advance before the use of cement bags brought and kept on site Stores. Cement bags required for testing shall be supplied by the contractor free of cost. If the tests prove unsatisfactory, then the charges for cement will be borne by the Contractor.
- c) The Contractor should store the cement of 60 days requirement at least one month in advance to ensure the quality of cement so brought to site and shall not remove the same without the written permission of the engineer-in-Charge. The Contractor should store the cement of 60 days requirement at least one month in advance to ensure the quality of cement so brought to site and shall not remove the same without the written permission of the engineer-in-Charge. The Contractor shall forthwith remove from the works area any cement that the Engineer-in-Charge may disallow for use, an account of failure to meet with required quality and standard.
- d) The contractor shall further, at all times satisfy the Engineer-in-Charge on demand, by production of records and books or by submission of returns and other proofs as directed, that the cement is being used as tested and approved by Engineer-in-Charge for the purpose and the Contractor shall at all times, keep his records up to date to enable the Engineer-in-Charge to apply such checks as he may desire.
- e) Cement which has been unduly long in storage with the contractor or alternatively has deteriorated due to inadequate storage and thus become unfit for use in the works will be rejected by the department and no claim will be entertained. The Contractor shall forthwith remove from the work area, any cement the Engineer-in-Charge may disallow for use on work and replace it by cement complying with the relevant Indian Standards.

3.24.14.3 Steel

The Contractor shall procure mild steel reinforcement bars, high yield strength deformed (HYSD) bars, rods and structural steel, etc., required for the works, only from the main or secondary producers manufacturing steel to the prescribed specifications of Bureau of Indian Standards or equivalent and licensed to affix ISI or other equivalent certification marks and acceptable to the Engineer-in-Charge. Necessary ISI list certificates are to be produced to Engineer-in-Charge before use on works. The unit weight and dimensions shall be as prescribed in the relevant Indian Standard specification for steel.

3.24.15.0 Supply of Construction Materials by The Employer

As it is a single responsibility contract supply, and/or arrange all materials and services including construction and testing equipment to complete the works in all respects described in the specification, shall be under the scope of the Contractor unless otherwise specifically mentioned elsewhere in the bidding document.

3.24.16.0 Miscellaneous General Requirements

3.24.16.1 Dense concrete with controlled water cement ratio as per IS-code shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness.

3.24.16.2 All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.

3.24.16.3 All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti-corrosive paint to take care of sea worthiness.

3.24.16.4 A screed concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to IS:456-1978 shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.

3.24.16.5 Bricks having minimum 75 kg/cm² compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75 kg/cm² compressive strength before submitting his offer.

3.24.16.6 Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sun-shade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.

3.24.16.7 All stairs shall have maximum riser height of 150 mm and a minimum tread width of 300 mm. Minimum width of stairs shall be 1500 mm. Service ladder shall be provided for access to all roofs. RCC fire escape staircase shall be provided in control buildings.

3.24.16.8 Angles 50 x 50 x 6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of manhole pre-cast cover and any other place where breakage of corners of concrete is expected.

3.24.16.9 Anti termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors etc. as per IS:6313 and other relevant Indian Standards.

3.24.16.10 Hand-railing minimum 900 mm high shall be provided around all floor/roof openings, projections/balconies, walk ways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanized (medium-class as per IS:277). All rungs for ladder shall also be galvanized as per IS: 277 medium classes.

For RCC stairs, hand railing with 20 mm square MS bars, balustrades with suitable MS flats shall be provided with black PVC sheathing.

3.24.16.11 The details given in tender drawings shall be considered along with details available in this section of the specification while deciding various components of the building.

3.24.16.12 Items/components of buildings not explicitly covered in the specification but required for completion of the project shall be deemed to be included in the scope.

3.25 TECHNICAL SPECIFICATION OF OUTDOOR POTENTIAL TRANSFORMERS

3.25.1 SCOPE

- 3.25.1.1 This Section of the Specification covers general requirements for design, engineering, manufacture, assembly and testing at manufacturer's works of Live Tank type outdoor Potential Transformers.
- 3.25.1.1 Loading at manufacturer's works, transportation and delivery at respective substation site including unloading at destination site.
- 3.25.1.2 Erection, Testing and Commissioning of Potential Transformers.

3.25.2 STANDARDS

- 3.25.2.1 The equipment covered by this specification shall, unless otherwise stated be designed, constructed and tested in accordance with the latest revisions of relevant Indian Standards or equivalent IEC and shall conform to the regulations of local statutory authorities.
- 3.25.2.1 In case of any conflict between the Standards and this specification, this specification shall govern.
- 3.25.2.2 The potential transformer shall comply also with the latest issue of the following Indian standard.
- (i). IS: 3156(Part-I): Potential transformers: General requirement.
 - (ii). IS: 3156 (Part-II): Potential transformers: Measuring Potential transformers
 - (iii). IS: 3156 (Part-III): Potential transformers: Protective Potential transformers

3.25.3 GENERAL REQUIREMENTS

- 3.25.3.1 The cores of the potential transformers shall be of high grade, non-aging CRC steel of low hysteresis loss and high permeability.
- 3.25.3.2 Instrument transformers shall be of **Live Tank design**.
- 3.25.3.3 The instrument transformers shall be truly hermetically sealed to completely prevent the oil inside the tank coming into contact with the outside temperature. To take care of oil volume variation the tenderer is requested to quote the current transformers with stainless steel diaphragm (bellow).
- All parts of bellow shall be stainless steel only. A ground glass window shall be provided to monitor the position of the metal bellow.**
- 3.25.3.4 The instrument transformers shall be completely filled with oil.
- 3.25.3.5 A complete leak proof secondary terminal arrangement shall be provided with each instrument transformers. All secondary terminals shall be brought out into weather, dust and vermin proof terminal box. Secondary terminal boxes shall be provided with facilities for easy earthing, shorting, insulating and testing of secondary circuits. The terminal boxes shall be suitable for connection of control cable gland.
- 3.25.3.6 All instrument transformers shall be of single-phase unit.
- 3.25.3.7 All Instrument transformers shall be suitable for upright mounting on latticed steel structures.
- 3.25.3.8 The Instrument Transformer shall be complete in all respects and shall conform to the modern practice of design and manufacture.
- 3.25.3.9 The instrument transformers shall be so designed to withstand the effects of temperature, wind load, short circuit conditions and other adverse conditions.
- 3.25.3.10 All similar parts, particularly removable ones, shall be interchangeable with one another.
- 3.25.3.11 All cable ferrules, lugs, tags, etc. required for identification and cabling shall be supplied complete for speedy erection and commissioning as per approved schematics.
- 3.25.3.12 The instrument transformers shall be designed to ensure that condensation of moisture is controlled by proper selection of organic insulating materials having low moisture absorbing characteristics.
- 3.25.3.13 All steel work shall be degreased, pickled and phosphate and then painted in accordance with as specified in the bid document.
- 3.25.3.14 The outer surface of metal tank shall be Hot Dip Galvanized, whereas, the inner portion shall be painted in accordance with as specified in bid document or hot dip galvanized.
- 3.25.3.15 The galvanising shall be as per applicable standard IS: 2629 and minimum thickness of zinc coating shall be 610 gm/sq.mt.

3.25.4 INSULATING OIL

3.25.4.1 The quantity of insulating oil for instrument transformers and complete specification of oil shall be stated in the tender. The insulating oil shall conform to the requirement of latest edition of IS: 335 / IEC 60296 (required for first filling)

3.25.5 COMMON MARSHALLING BOXES

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

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

3.25.5.3 1(One) common marshalling box shall be supplied with each set of instrument transformers. The marshalling box shall be made of sheet steel and weather proof. The thickness of sheet steel used shall be not less than 3.0 mm. It is intended to bring all the secondary terminals to the common marshalling.

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

3.25.5.5 The common marshalling boxes shall be provided with double hinged front doors with pad locking arrangement. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement.

3.25.5.6 Each marshalling box shall be fitted with terminal blocks made out of moulded non-inflammable plastic materials and having adequate number of terminals with binding screws washers etc. Secondary terminals of the instrument transformers shall be connected to the respective common marshalling boxes. All out going terminals of each instrument transformer shall terminate on the terminal blocks of the common marshalling boxes. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminals.

3.25.5.7 Each terminal shall be suitably marked with identification numbers. Not more than two wires shall be connected to any one terminal. At least 20 % spare terminals shall be provided over and above the required number.

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

3.25.5.9 All cable entries shall be from bottom. Suitable removable gland plate shall be provided on the box for this purpose. Necessary number of cable glands shall be supplied fitted on to this gland plate. Cable glands shall be screw on type and made of brass.

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

3.25.5.11 All steel works of common marshalling boxes shall be hot dipped galvanized.

3.25.5.12 All steel, inside and outside work shall be degreased, pickled and phosphate and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint. The colour of finishing paint shall be as follows: -

(i). Inside: Glossy White

(ii). Outside: Light Grey (Shade No. 697 of IS: 5)

3.25.6 BUSHINGS AND INSULATORS

3.25.6.1 Bushings and Insulators shall be of Porcelain, Solid core type. Porcelain used for the manufacture of bushings and insulators shall be homogeneous, free from defects, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

3.25.6.2 Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. Bushings shall be designed to have sufficient mechanical strength and rigidity for the conditions under which they will be used. All bushings of identical ratings shall be interchangeable.

3.25.6.3 Puncture strength of bushings shall be greater than the dry flashover value. When operating at normal voltage, there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the bushings when operating at the normal rated voltage.

3.25.6.4 The design of bushing shall be such that the complete bushing is a self-contained unit and no audible discharge shall be detected at a voltage up to a working voltage (Phase Voltage) plus 10%. The minimum creepage distance for severely polluted atmosphere shall be 25 mm/KV.

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

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

3.25.7 TESTS

3.25.7.1 Routine/Acceptance Tests (all units)

3.25.7.1.1 All routine tests shall be carried out in accordance with relevant Standards.

All routine/acceptance tests shall be witnessed by the Purchaser/his authorised representative.

3.17.1.1.2 In addition, following tests on Current Transformers shall also be carried out as Routine Tests:

- (i). Measurement of Capacitance.
- (ii). Oil leakage test.
- (iii). Measurement of tan delta at 0.3, 0.7, 1.0 $U_m/\sqrt{3}$ and 10 kV

3.17.1.1.3 At factory/works tests the Tan Delta shall not exceed 0.3% (at $U_m/\sqrt{3}$). The same shall not exceed 0.7% at the end of warranty period (refer SCC clause 5.10.0 of Vol-1). If tan delta value of CTs exceed prescribed limit of 0.7% within warranty period, it will be considered as failure within warranty period (Tan delta & capacitance test of CTs shall be measured at 10KV at site). The bidder has to replenish failed CTs within guarantee period without any cost implication to AEGCL.

3.25.7.2 Type Tests

3.25.7.2.1 The bidder shall furnish type test certificates and results for the all tests as per relevant Standards along with the bid for current and potential transformers of identical design.

3.25.8 NAME PLATES

3.25.8.1 All equipment shall have non-corrosive name plates conforming to requirements of IS and fix at a suitable position and indelibly marked with full particular there on in accordance with the standard adapted.

The rated current, extended current rating (if specified) along with year of manufacture must be clearly indicated on the name plate.

The rated thermal current in case of CT shall also be marked on the name plate.

3.25.9 MOUNTING STRUCTURES

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

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

3.25.10 SAFETY EARTHING

3.25.10.1 The non-current carrying metallic parts and equipment shall be connected to station earthing grid. For these two terminals suitable for 40mm X 10mm GI strip shall be provided on each equipment.

3.25.11 TERMINAL CONNECTORS

3.25.11.1 The equipment shall be supplied with required number of terminal connectors of approved type suitable for ACSR. The type of terminal connector, size of connector, material, and type of installation shall be approved by the Purchaser, as per installation requirement while approving the equipment drawings.

3.25.12 PRE-COMMISSIONING TESTS

3.25.12.1 Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for

conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval:

(a) Current Transformers

- i) Insulation Resistance Test for primary and secondary.
- ii) Polarity test
- iii) Ratio identification test - checking of all ratios on all cores by primary injection of current.
- iv) Dielectric test of oil (wherever applicable).
- v) Magnetising characteristics test.
- vi) Tan delta and capacitance measurement.
- vii) Secondary winding resistance measurement
- viii) Contact resistance measurement (wherever possible/accessible)

(b) Voltage Transformers

- i) Insulation Resistance Test for primary (if applicable) and secondary.
- ii) Polarity test.
- iii) Ratio test.
- iv) Dielectric test of oil (wherever applicable).
- v) Tan delta and capacitance measurement of individual capacitance stacks.
- vi) Secondary winding resistance measurement

3.25.13 TECHNICAL DATA SHEET FOR CURRENT AND POTENTIAL TRANSFORMERS

3.25.13.1 For 220,132 & 33 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired up to the terminal blocks.

3.25.14 TYPE AND RATING:

All potential transformer shall be outdoor type, single phase, oil immersed, self-cooled suitable for mounting on steel structure. The potential transformer shall have the following ratings and particulars.

Item		Ratings and Particulars		
(A)	Nominal system voltage	220kV	132kV	33 kV
(B)	Highest system voltage, kV	245	145	36
(C)	Rated frequency, HZ	50	50	50
(D)	System earthing	Solidly Earthed	Solidly earth	Solidly earth
(E) Insulation level				
(a)	Impulse withstand voltage: kVp	1050	550	170
(b)	One-minute p.f. Withstand voltage, kV (r.m.s.)	460	230	70
(F)	Short time current for one second, kA	40	31.5	25
(G)	Minimum creepage distance, mm	6125	3625	1800
(a)	Tan Delta (for CTs only) at $U_m/\sqrt{3}$, (Max)	0.3%	0.3%	0.3%
(H)	Temperature rise	As per ISS		
POTENTIAL TRANSFORMER				
(i)	No. of secondary windings	3	2	2
(ii)	Transformation ratio			
(a)	Winding I	$(220 \text{ kV}/\sqrt{3})$ $/ (110 \text{ V}/\sqrt{3})$	$(132\text{kV}/\sqrt{3})$ $/ (110\text{V}/\sqrt{3})$	$33\text{kV}/\sqrt{3}$ $/ 110\text{V}/\sqrt{3}$
(b)	Winding II			
(c)	Winding III		-	
(iii)	Rated out put			

Supply, ETC and Associated Works for Augmentation of 2x100 MVA, 220/132 KV Rangia GSS By 2x200 MVA Auto-Transformer (Phase-II)

(a) Winding I		500	200
(b) Winding II		200	100
(vi) Accuracy class			
(a) Winding I		0.2	0.2
(b) Winding II		3P	3P
(v) Rated voltage factor		1.2	1.2

Note:

- (i) It is intended to use different ratios of the same CT at the same time for various protections and metering cores.
- (ii) The CTS should therefore be suitable for the above purpose by secondary tapings only.
- (iii) The ratio change by secondary taps is acceptable as long as the required CT specifications are achieved at all ratios.
- (iv) The knee point voltage specified above shall be at higher ratio/ taps.

CHAPTER 3.26: SUB STATION AUTOMATION SYSTEM**3.26.1 GENERAL**

The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system **which must be in satisfactory operation for at least 3 (three) years as on the date of bid opening**. KEMA/ Internationally and nationally accredited certificate for all IEDs and Ethernet switches conforming to IEC 61850 is to be furnished as qualification requirement.

Please Note: The integration of existing CRP to the existing SAS (Hitachi Energy make at 220kV Rangia GSS) has to be done by authorized representatives of the OEM only.

Any upgradation of hardware and software for above integration shall be in the scope of contractor including licence upgradation (if required) if specified in the Price Schedule or BoQ. The validity of the licence upgraded should be minimum of 10 years.

Standards**Environment Standards**

All these standards are applicable to elements like HMI, Ethernet network and elements, Gateways, IEDs.

Type Test Name	Type Test Standard	Conditions
Insulation Resistance	IEC 60255-5	100 MΩ at 500 Vdc (CM & DM)
Dielectric Withstand	IEC60255-5 IEEE C37.90	50 Hz, 1mn, 2kV (CM), 1kV (DM)
		50 Hz, 1mn, 1kV (CM)
		G 1.4 & 1.5 500V CM 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

Type Test Name	Type Test Standard	Conditions
		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)

Type Test Name	Type Test Standard	Conditions
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 IEEE C37.90.2	Class 3 : 10 V/m – 80 to 1000 MHz & spot tests
		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

Type Test Name	Type Test Standard	Conditions
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 in case 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 disconnecter, earth switches and instrument transformer) Level Functions
- b). System Level Functions

3.26.6. BAY LEVEL FUNCTIONS

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions **including data collection in bay control / protection unit.**
- Bay protection functions with support of Numerical Relays defined in CRP Section.

3.26.7. Bay Control Functions

Overview

Functions:

- Control mode selection
- Select-before-execute principle
- Command supervision:
 - ✓ Interlocking and blocking
 - ✓ Double command
- Synchro-check, voltage selection
- Run Time Command cancellation
- Transformer Tap Changer control (raise / lower tap) (for Power Transformer bays)
- Operation counters for Circuit Breakers and Pumps.
- Transformer cooling gear, pump control and runtime supervision
- Operating pressure Monitoring & supervision (CB SF6 Gas Pressure, CB Operating Pneumatic Pressure / spring status).
- Display of interlocking and blocking
- Breaker position indication (per phase for single pole)
- Alarm annunciation
- Measurement display. (Electrical Parameters & Transformer Parameters)
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 500 events
- Extension possibilities with additional I/O's inside the unit or via fiber optic communication and process bus

Control mode selection

Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED.

REMOTE mode

Control authority in this mode is given to a higher level (Remote SCADA) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- Settable voltage, phase angle, and frequency difference.
- Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.
- Synchronizing between live line and live bus with synchro-check function

Voltage selection

The voltages relevant for the Synchro-check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

Transformer Tap Changer control

Raise and lower operation of OLTC taps of Transformer shall be facilitated through Bay controller IED.

Protection Transfer Control

From BCU, necessary control shall be provided for transferring bay to TBC.

3.26.8. Bay Protection Functions

General

The Protection functions are independent of Bay Control function. The Protection shall be provided by separate Protection IEDs (numerical relays) and other Protection devices as per section Relay & Protection.

IEDs shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. This shall give alarm if 70% memory is full. The disturbance recorder function shall be as detailed in section C&R.

Bay Monitoring Functions

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.26.9. SYSTEM LEVEL FUNCTIONS

Status Supervision

- Continuous monitoring of switching objects i.e. the position of each switchgear, e.g. Circuit Breaker, Isolator, Earthing Switch, Transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station
- HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

- The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.
- The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through dedicated one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

Measurements

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms, Max / Min values for voltage (U) and current (I) shall be calculated.

In case of Circuit Breaker SF6 Gas Pressure, Operating Mechanism Pressure (i.e. Pneumatic, Spring), if SF6 CTs are Utilizing the Pressure of SF6 Gas, Transformer Oil/ Winding temperatures, Firefighting or any Other with Transformer management Relay and OLTC Tap Position can be interfaced with BCU through Transducers. Max / Min values for the above parameters shall be calculated. These parameters shall appear in Substation Automation System at Local HMI and can monitor regularly.

The measured values shall be displayed locally on the station HMI and in the control center. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

The SAS shall also poll data from the Meter Server to gateway for onward communication to RCC.

Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. **The tentative list of event/ alarm for various feeders and systems are enclosed as Annexure-II and is not exhaustive, there may be addition during detail engineering or at the time of commissioning.**

3.26.10. Station HMI

Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking condition are not met; the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

Presentation and dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks or keyboard commands.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

- ✓ Single-line diagram showing the switchgear status, Pressure values (wherever required) and measured values (current, voltage, apparent power, freq & pf) including OLTC Tap Position, WTI, OTI & Analog set values.
- ✓ Control dialogues with interlocking and blocking details. This control dialogue shall tell the operator whether the device operation is permitted or blocked & Select before Execute.
- ✓ Measurement dialogues, Statistics & Trends
- ✓ Bay wise interlock status display and failure of any interlock within the bay by generating alarm and indication in Interlock diagram window.
- ✓ Alarm list, station / bay-oriented
- ✓ Event list, station / bay-oriented
- ✓ Substation Auxiliaries
- ✓ System status
- ✓ Printing of sequence of event list, hardcopy and reports. The reports shall be freely configurable using Crystal Report

List of signals to be configured in SAS is mentioned in Annexure-II of this chapter.

HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- ✓ Selected object under command
- ✓ Selected on the screen
- ✓ Not updated, obsolete values, not in use or not sampled
- ✓ Alarm or faulty state
- ✓ Warning or blocked
- ✓ Update blocked or manually updated
- ✓ Control blocked
- ✓ Normal state

Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In addition to above Transformer WTIs, OTI, SF6 gas Pressures of Circuit breakers , CTs and CB Operating mechanism Pressures shall also be displayed.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

System Supervision and Display

The SAS system shall be comprehensively self-monitoring such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure, protection couplers and remote communication links, and printers at the station level, etc.

Event List

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with 1ms resolution) of its occurrence has to be displayed for each event. The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer/Dot matrix Printer / Line Printer of 132 Column.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurand.
- Loss of communication.
- Hourly time Stamping

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

Alarm List

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

Object picture

When selecting an object such as a circuit breaker or isolator in the single line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking
 - Authority
 - Local / remote control
 - SLDC / SAS control
 - Errors
- etc. shall be displayed.

Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. It shall also be possible to use the keyboard for command activation. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and Disconnecter
- 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 $AOH = \Sigma AOD$

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

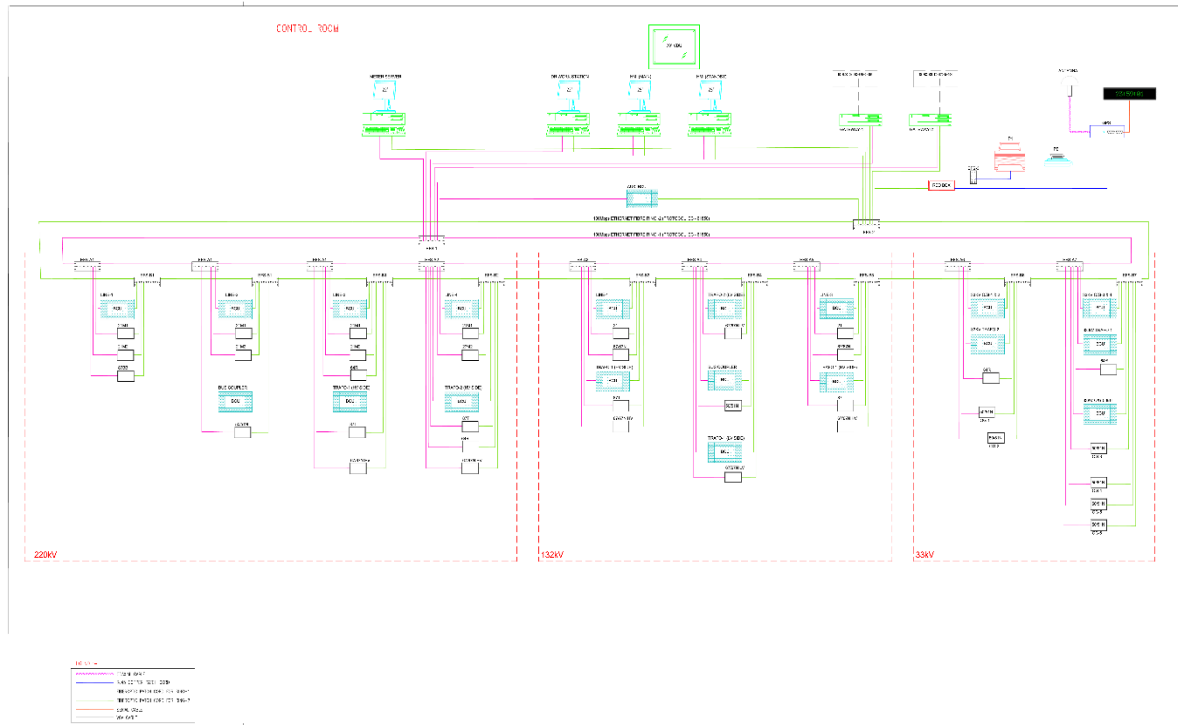
period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

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



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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 , $\Delta \phi$; 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

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- 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

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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	

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B Configuration of Digital Channels for 32 channels					
S.No.	Channel Description	(Limited to 16 Characters)	7 characters	Triggers	COMMENTS
18	POWER SWING BLOCK OPERATED	PS BLK OPTD	PSB_OP	N	
19	STUB/TEED OPERATED	STUB_OPTD	SB_OPD	Y	Where ever Applicable
20	BUSBAR OPERATED (M1/M2)	BUSBAR_OPTD	BB_OPD	Y	
21	MAIN/TIE LBB OPERATED	M/T_LBB_OPTD	M/T_LBB	Y	
22	MAIN 1 ZONE-1 OPTD.	MAIN1_Z1_OPTD	M1Z1_OP	Y	
23	MAIN 1 ZONE-2 START	MAIN1_Z2_START	M1Z2_ST	N	
24	MAIN 1 ZONE-2 OPTD.	MAIN1_Z2_OPTD	M1Z2_OP	Y	
25	MAIN 1 ZONE-3 START	MAIN1_Z3_START	M1Z3_ST	N	
26	MAIN 1 ZONE-3 OPTD.	MAIN1_Z3_OPTD	M1Z3_OP	Y	
27	MAIN 1 REVERSE ZONE OPTD	MAIN1_ZR_OPTD	M1ZR_OP	Y	
28	MAIN 1/2 SOTF OPTD	M1/2_SOTF_OPD	M12SOTF	Y	
29	MAIN 1/2 DEF OPTD	DEF_OPD	DEF_OPD	Y	MAIN-1/2
30	MAIN1/2 CARR. SEND	M1/2 CARR. SEND	M12CRSD	N	MAIN-1/2
31	DIRECT TRIP SEND	DIR_TR SEND	DT_SEND	Y	
32	CARRIER AIDED TRIP	CARR_AID_TRIP	CAR_AID	Y	

MAIN-2		
A	Configuration of ANALOG CHANNELS	
S.No	Channel Description	Standardized Channel Name
1	R Phase Current	I-R PH.
2	Y Phase Current	I-Y PH.
3	B Phase Current	I-B PH.
4	Neutral Current	I-N PH.
5	R Phase Voltage	V-R PH.
6	Y Phase Voltage	V-Y PH.
7	B Phase Voltage	V-B PH.
8	Open Delta Voltage	V-N (Open Delta)

B Configuration of Digital Channels for 32 channels					
S.No.	Channel Description	(Limited to 16 Characters)	7 characters	Triggers	COMMENTS
1	MAIN CB R-PHASE OPEN	MAIN_CB_R_OPEN	M CB_RO	Y	
2	MAIN CB Y-PHASE OPEN	MAIN_CB_Y_OPEN	M CB_YO	Y	
3	MAIN CB B-PHASE OPEN	MAIN_CB_B_OPEN	M CB_BO	Y	
4	TIE CB R-PHASE OPEN	TIE_CB_R_OPEN	T CB_RO	Y	
5	TIE CB Y-PHASE OPEN	TIE_CB_Y_OPEN	T CB_YO	Y	
6	TIE CB B-PHASE OPEN	TIE_CB_B_OPEN	T CB_BO	Y	

CHAPTER 3.26: SUBSTATION AUTOMATION SYSTEM

B Configuration of Digital Channels for 32 channels					
S.No.	Channel Description	(Limited to 16 Characters)	7 characters	Triggers	COMMENTS
7	MAIN1 TRIP	MAIN1_TRIP	M1_TRIP	Y	MAIN-1
8	MAIN2 TRIP	MAIN2_TRIP	M2_TRIP	Y	
9	MAIN 2 ZONE-1 OPTD.	MAIN2_Z1_OPTD	M2Z1_OP	Y	
10	MAIN 2 ZONE-2 START	MAIN2_Z2_START	M2Z2_ST	N	
11	MAIN 2 ZONE-2 OPTD.	MAIN2_Z2_OPTD	M2Z2_OP	Y	
12	MAIN 2 ZONE-3 START	MAIN2_Z3_START	M2Z3_ST	N	
13	MAIN 2 ZONE-3 OPTD.	MAIN2_Z3_OPTD	M2Z3_OP	Y	
14	MAIN 2 REVERSE ZONE START	MAIN2_ZR_START	M2ZR_ST	N	
15	MAIN 2 REVERSE ZONE OPTD	MAIN2_ZR_OPTD	M2ZR_OP	Y	
16	POWER SWING DET.	PS_DETECTED	PS_DET	N	
17	POWER SWING BLOCK OPERATED	PS BLK OPTD	PSB_OP	N	
18	OVER VOLTAGE STAGE-1 OPERATED	O/V_STG1_OPTD	O/V_ST1	Y	
19	OVER VOLTAGE STAGE-2 OPERATED	O/V_STG2_OPTD	O/V_ST2	Y	
20	MAIN/TIE CB POLE DISCREPANCY	M/T_CB_POLE_DISC	M/T_PLDSC	N	
21	CARRIER AIDED TRIP	CAR_AID_TRP	CAR_TRP	Y	
22	MAIN-1 VT FUSE FAIL	VT_FUS_FAIL_M1	VT_FF_M1	N	MAIN-1
23	MAIN-2 VT FUSE FAIL	VT_FUS_FAIL_M2	VT_FF_M2	N	
24	MAIN-2 CARRIER RECEIVE	MAIN2_CARR_REC	M2_CR_RC	N	
25	OPTIONAL				
26	OPTIONAL				
27	OPTIONAL				
28	OPTIONAL				
29	OPTIONAL				
30	OPTIONAL				
31	OPTIONAL				
32	OPTIONAL				

MAIN-1/2					
Configuration of Digital Channels for 16 channels					
S.No.	DIGITAL CHANNELS	(Limited to 16 Characters)	7 characters	Triggers	
1	MAIN CB R-PHASE OPEN	MAIN_CB_R_OPEN	M CB_RO	Y	
2	MAIN CB Y-PHASE OPEN	MAIN_CB_Y_OPEN	M CB_YO	Y	
3	MAIN CB B-PHASE OPEN	MAIN_CB_B_OPEN	M CB_BO	Y	
4	TIE CB R-PHASE OPEN	TIE_CB_R_OPEN	T CB_RO	Y	
5	TIE CB Y-PHASE OPEN	TIE_CB_Y_OPEN	T CB_YO	Y	

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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	

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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)

CHAPTER 3.26: SUBSTATION AUTOMATION SYSTEM

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
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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_OPTD	DEF_OPTD	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_OPTD	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

CHAPTER 3.26: SUBSTATION AUTOMATION SYSTEM

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
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CHAPTER 3.26: SUBSTATION AUTOMATION SYSTEM

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

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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

CHAPTER 3.26: SUBSTATION AUTOMATION SYSTEM

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	
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CHAPTER 3.26: SUBSTATION AUTOMATION SYSTEM

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	

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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

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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)	DIFFERENTIAL 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

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REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS			
SL. NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED
22	SPI	OTI B PH ALARM	Y
23	SPI	OTI SPARE ICT ALARM	Y
24	SPI	WTI HV R PH ALARM	Y
25	SPI	WTI HV Y PH ALARM	Y
26	SPI	WTI HV B PH ALARM	Y
27	SPI	WTI HV SPARE ICT ALARM	Y
28	SPI	WTI MV R PH ALARM	Y
29	SPI	WTI MV Y PH ALARM	Y
30	SPI	WTI MV B PH ALARM	Y
31	SPI	WTI MV SPARE ICT ALARM	Y
32	SPI	WTI IV R PH ALARM	Y
33	SPI	WTI IV Y PH ALARM	Y
34	SPI	WTI IV B PH ALARM	Y
35	SPI	WTI IV SPARE ICT ALARM	Y
36	SPI	BUCCHOLZ R PH TRIP	Y
37	SPI	BUCCHOLZ Y PH TRIP	Y
38	SPI	BUCCHOLZ B PH TRIP	Y
39	SPI	BUCCHOLZ SPARE ICT TRIP	Y
40	SPI	OSR 1 R PH TRIP	Y
41	SPI	OSR 1 Y PH TRIP	Y
42	SPI	OSR 1 B PH TRIP	Y
43	SPI	OSR 1 SPARE ICT TRIP	Y
44	SPI	PRD 1 R PH TRIP	Y
45	SPI	PRD 1 Y PH TRIP	Y
46	SPI	PRD 1 B PH TRIP	Y
47	SPI	LOW OIL LEVEL R PH	Y
48	SPI	LOW OIL LEVEL Y PH	Y
49	SPI	LOW OIL LEVEL B PH	Y
50	SPI	LOW OIL LEVEL SPARE ICT	Y
51	SPI	FIRE PROTECTION R PH OPERATED	Y
52	SPI	FIRE PROTECTION Y PH OPERATED	Y
53	SPI	FIRE PROTECTION B PH OPERATED	Y
54	SPI	FIRE PROTECTION SPARE ICT OPERATED	Y
55	SPI	MAIN CB R PH OPEN	
56	SPI	MAIN CB Y PH OPEN	

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REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS			
SL. NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED
57	SPI	MAIN CB B PH OPEN	
58	SPI	TIE CB R PH OPEN	
59	SPI	TIE CB Y PH OPEN	
60	SPI	TIE CB B PH OPEN	
61	SPI	TRIP RELAY 86 A HEALTHY (SUPERVISION)	Y
62	SPI	TRIP RELAY 86 B HEALTHY (SUPERVISION)	Y
63	SPI	GR A RELAY OPERATED	Y
64	SPI	GR B RELAY OPERATED	Y
65	SPI	REF RELAY FAIL	Y
66	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
67	SPI	ANY ADDITIONAL SIGNAL AS PER SCHEME	

REQUIRED SIGNALS FOR ICT REF RELAYS			
SL. NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED
1	SPI	OVEREXCITATION MV START	
2	SPI	OVEREXCITATION MV ALARM	Y
3	SPI	OVEREXCITATION MV TRIP	Y
4	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y
5	System Diagnosis (SON)	DIFFERENTIAL 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

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REQUIRED SIGNALS FOR ICT REF RELAYS			
SL. NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED
18	SPI	OTI Y PH TRIP	Y
19	SPI	OTI B PH TRIP	Y
20	SPI	OTI SPARE ICT TRIP	Y
21	SPI	WTI HV R PH TRIP	Y
22	SPI	WTI HV Y PH TRIP	Y
23	SPI	WTI HV B PH TRIP	Y
24	SPI	WTI HV SPARE ICT TRIP	Y
25	SPI	WTI MV R PH TRIP	Y
26	SPI	WTI MV Y PH TRIP	Y
27	SPI	WTI MV B PH TRIP	Y
28	SPI	WTI MV SPARE ICT TRIP	Y
29	SPI	WTI IV R PH TRIP	Y
30	SPI	WTI IV Y PH TRIP	Y
31	SPI	WTI IV B PH TRIP	Y
32	SPI	WTI IV SPARE ICT TRIP	Y
33	SPI	BUCCHOLZ R PH ALARM	Y
34	SPI	BUCCHOLZ Y PH ALARM	Y
35	SPI	BUCCHOLZ B PH ALARM	Y
36	SPI	BUCCHOLZ SPARE ICT ALARM	Y
37	SPI	OSR 2 R PH TRIP	Y
38	SPI	OSR 2 Y PH TRIP	Y
39	SPI	OSR 2 B PH TRIP	Y
40	SPI	OSR 2 SPARE ICT TRIP	Y
41	SPI	PRD 2 R PH TRIP	Y
42	SPI	PRD 2 Y PH TRIP	Y
43	SPI	PRD 2 B PH TRIP	Y
44	SPI	PRD 2 SPARE ICT TRIP	Y
45	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y
46		ANY ADDITIONAL SIGNAL AS PER SCHEME	

REQUIRED SIGNALS FOR DIRECTIONAL OVERCURRENT AND EARTH FAULT RELAYS			
SL. NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED
1	SPI	DEF START	
2	SPI	DEF GEN TRIP	Y

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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

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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		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

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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)	DIFFERENTIAL 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

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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

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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		

CHAPTER 3.26: SUBSTATION AUTOMATION SYSTEM

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED	ADDITIONAL REMARKS
7	SPI	BAY_CB_CLOSE PERMITTED OR ENABLED		
8	DPI	BAY_CB R PH POSITION		
9	DPI	BAY_CB Y PH POSITION		
10	DPI	BAY_CB B PH POSITION		
11	DPI	BAY_89A_ISOLATOR POSITION		
12	CMD	BAY_89A_ISO COMMAND		
13	SPI	BAY_89A_ISO OPEN PERMITTED OR ENABLED		
14	SPI	BAY_89A_CLOSE PERMITTED OR ENABLED		
15	DPI	BAY_89AE_ISOLATOR POSITION		IF BUS EARTH SWITCH IS IN THE BAY FOR WHICH THE ASSIGNMENT IS BEING DONE, CSWI3 SHALL BE USED FOR 89 AE 1, i.e. BUS EARTH SWITCH. FOR BAY SIDE EARTH SWITCH (89AE2) SEPARATE LOGICAL NODE CSWI 10 IS PROVIDED BELOW
16	CMD	BAY_89AE_ISO COMMAND		
17	SPI	BAY_89AE_ISO OPEN PERMITTED OR ENABLED		
18	SPI	BAY_89AE_CLOSE PERMITTED OR ENABLED		
19	DPI	BAY_89 B_ISOLATOR POSITION		
20	CMD	BAY_89 B_ISO COMMAND		
21	SPI	BAY_89 B_ISO OPEN PERMITTED OR ENABLED		
22	SPI	BAY_89 B_CLOSE PERMITTED OR ENABLED		
23	DPI	BAY_89 BE_ISOLATOR POSITION		
24	CMD	BAY_89 BE_ISO COMMAND		
25	SPI	BAY_89 BE_ISO OPEN PERMITTED OR ENABLED		
26	SPI	BAY_89 BE_CLOSE PERMITTED OR ENABLED		

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REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED	ADDITIONAL REMARKS
27	DPI	BAY_89 C/L/T_ISOLATOR POSITION		FOR 3 PHASE TRANSFORMERS CSW17 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 CSW17 MAY BE USED FOR 89 TE BUT FOR SINGLE PHASE TRANSFORMERS SAME HAS BEEN SEPARATELY MENTIONED
32	CMD	BAY_89 CE/LE/TE_ISO COMMAND		
33	SPI	BAY_89 CE/LE/TE_ISO OPEN PERMITTED OR ENABLED		
34	SPI	BAY_89 CE/LE/TE_CLOSE PERMITTED OR ENABLED		
35	DPI	BAY_89 R_ISOLATOR POSITION		
36	CMD	BAY_89 R_ISO COMMAND		
37	SPI	BAY_89 R_ISO OPEN PERMITTED OR ENABLED		
38	SPI	BAY_89 R_CLOSE PERMITTED OR ENABLED		
39	DPI	BAY_89 RE_ISOLATOR POSITION		
40	CMD	BAY_89 RE_ISO COMMAND		
41	SPI	BAY_89 RE_ISO OPEN PERMITTED OR ENABLED		
42	SPI	BAY_89 RE_CLOSE PERMITTED OR ENABLED		
43	DPI	BAY_89AE 2_ISOLATOR POSITION		USED FOR SECOND EARTH SWITCH OF ISOLATOR, WHEN BUS EARTH SWITCH IS PROVIDED
44	CMD	BAY_89AE 2_ISO COMMAND		
45	SPI	BAY_89AE 2_ISO OPEN PERMITTED OR ENABLED		
46	SPI	BAY_89AE 2_CLOSE PERMITTED OR ENABLED		
<p>THE LOGICAL NODES FOR ISOLATOR & EARTH SWITCHES FOR 3 PH ICTs & REACTORS , e.g 89 RR,RR1,RR2 & RE and for 89TR,TR1,TR2,TRE MAY BE ASSIGNED AS PER AVAILABILITY</p>				

CHAPTER 3.26: SUBSTATION AUTOMATION SYSTEM

REQUIRED SIGNALS FOR BAY CONTROL UNIT				
SL.NO.	TYPE	EVENT/ALARM NAME	WHETHER ALARM TO BE GENERATED	ADDITIONAL REMARKS
47	System Diagnosis (SON)	TIME SYNCHRONIZATION ERROR	Y	
48	System Diagnosis (SON)	BCU UNHEALTHY	Y	
49	SPI	CONDITIONS OK FOR SYNCHRONIZATION		
50	SPI	SPRING DISCHARGED	Y	ANNUNCIATION FOR CIRCUIT BREAKER
51	SPI	AC MOTOR SUPPLY FAIL	Y	
52	SPI	SF6 GAS LOW	Y	
53	SPI	OPERATION LOCKED OUT	Y	
54	SPI	CB READY FOR AUTORECLOSURE	Y	
55	SPI	DC SUPPLY FAIL	Y	
56	SPI	TC-1 FAIL	Y	
57	SPI	TC-2 FAIL	Y	
58	SPI	POLE DISCREPANCY RELAY OPTD	Y	
59	SPI	COMPRESSOR SUPPLY FAIL	Y	
60	SPI	AIR PRESSURE LOW	Y	
61	SPI	COMPRESSOR RUN TIME SUPERVISION	Y	
62	SPI	CSD FAIL	Y	
63	SPI	GAS COMPARTMENT n Alarm Stage n	Y	
64	SPI	LCC PANEL AC SUPPLY FAIL	Y	
65	SPI	LCC PANEL DC SUPPLY FAIL	Y	
66	SPI	SELECTOR SWITCH POSITION LOCAL/REMOTE	Y	
67	SPI	BUS VT MCB TRIP	Y	FOR BCUs HAVING BUS VT INPUT
6	SPI	GOOSE RECEIPT FAIL/TROUBLE	Y	
68	SPI	ADDL SIGNALS FOR CB TROUBLE ETC AS PER SCHEME		

6. List of Signal for Station Auxiliaries Panel (SAS)

110V DC

1. Voltage of 110V DCDB-1
2. Voltage of 110V DCDB-2
3. Current from 110V Battery Set -1

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4. Current from 110V Battery Set -2
5. Current from 110V Battery Charger -1
6. Current from 110V 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 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)

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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 .