

# STANDARDS/MANUALS/ GUIDE LINES FOR SMALL HYDRO DEVELOPMENT

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**3.8**

**Electro-Mechanical–  
Technical Specifications for Procurement and Installation of  
Switchyard Equipment**

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Sponsor:

Ministry of New and Renewable Energy  
Govt. of India

Lead Organization:

Alternate Hydro Energy Centre  
Indian Institute of Technology Roorkee

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*AHEC-IITR, “3.8 Electro-Mechanical – Technical specification for procurement and installation of switchyard equipment”, standard/manual/guideline with support from Ministry of New and Renewable Energy, Roorkee, November 2012.*

## **PREAMBLE**

There are series of standards, guidelines and manuals on electrical, electromechanical aspects of moving machines and hydro power from Bureau of Indian Standards (BIS), Rural Electrification Corporation Ltd (REC), Central Electricity Authority (CEA), Central Board of Irrigation & Power (CBIP), International Electromechanical Commission (IEC), International Electrical and Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME) and others. Most of these have been developed keeping in view the large water resources/ hydropower projects. Use of the standards/guidelines/manuals is voluntary at the moment. Small scale hydropower projects are to be developed in a cost effective manner with quality and reliability. Therefore a need to develop and make available the standards and guidelines specifically developed for small scale projects was felt.

Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee initiated an exercise of developing series of standards/guidelines/manuals specifically for small scale hydropower projects with the sponsorship of Ministry of New and Renewable Energy, Government of India in 2006. The available relevant standards / guidelines / manuals were revisited to adapt suitably for small scale hydro projects. These have been prepared by the experts in respective fields. Wide consultations were held with all stake holders covering government agencies, government and private developers, equipment manufacturers, consultants, financial institutions, regulators and others through web, mail and meetings. After taking into consideration the comments received and discussions held with the lead experts, the series of standards/guidelines/manuals are prepared and presented in this publication.

The experts have drawn some text and figures from existing standards, manuals, publications and reports. Attempts have been made to give suitable reference and credit. However, the possibility of some omission due to oversight cannot be ruled out. These can be incorporated in our subsequent editions.

This series of standards / manuals / guidelines are the first edition. We request users to send their views / comments on the contents and utilization to enable us to review for further upgradation.

Standards/ Manuals/Guidelines series for Small Hydropower Development

<b>General</b>	
1.1	Small hydropower definitions and glossary of terms, list and scope of different Indian and international standards/guidelines/manuals
1.2 Part I	Planning of the projects on existing dams, Barrages, Weirs
1.2 Part II	Planning of the Projects on Canal falls and Lock Structures.
1.2 Part III	Planning of the Run-of-River Projects
1.3	Project hydrology and installed capacity
1.4	Reports preparation: reconnaissance, pre-feasibility, feasibility, detailed project report, as built report
1.5	Project cost estimation
1.6	Economic & Financial Analysis and Tariff Determination
1.7	Model Contract for Execution and Supplies of Civil and E&M Works
1.8	Project Management of Small Hydroelectric Projects
1.9	Environment Impact Assessment
1.10	Performance evaluation of Small Hydro Power plants
1.11	Renovation, modernization and uprating
1.12	Site Investigations
<b>Civil works</b>	
2.1	Layouts of SHP projects
2.2	Hydraulic design
2.3	Structural design
2.4	Maintenance of civil works (including hydro-mechanical)
2.5	Technical specifications for Hydro Mechanical Works
<b>Electro Mechanical works</b>	
3.1	Selection of Turbine and Governing System
3.2	Selection of Generators and Excitation Systems
3.3	Design of Switchyard and Selection of Equipment, Main SLD and Layout
3.4	Monitoring, control, protection and automation
3.5	Design of Auxiliary Systems and Selection of Equipments
3.6	Technical Specifications for Procurement of Generating Equipment
3.7	Technical Specifications for Procurement of Auxiliaries
3.8	Technical Specifications for Procurement and Installation of Switchyard Equipment
3.9	Technical Specifications for monitoring, control and protection
3.10	Power Evacuation and Inter connection with Grid
3.11	operation and maintenance of power plant
3.12	Erection Testing and Commissioning

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# TECHNICAL SPECIFICATIONS FOR PROCUREMENT AND INSTALLATION OF SWITCHYARD EQUIPMENT

## 1.0 INTRODUCTION

### 1.1 SCOPE

The guide include scope, design conditions, performance guarantee, general arrangement, constructional features, shop assembly and tests, site installation testing and commissioning of different type of switchyard equipments

### 1.2 References

All equipment shall comply with latest edition of relevant Indian standard specifications or relevant international standards. When the equipments do not comply with standards listed in Table 1, the salient point of difference between the standards adopted and the relevant Indian standard or relevant International standard shall be clearly brought out.

**Table 1: List of International and Indian Standards for Main Equipment**

R1	IS:2026-2006	Transformer specification
R2	IS2099-2003	Specification for busting for alternating voltages above 1000 V
R3	IEC:60761-2002	Specific requirement for tritium monitors
R4	IEC:60376-2005	SF <sub>6</sub> Circuit Breaker
R5	IS:13118-2002	High voltage alternating current circuit breakers
R6	IS:13947-2004	Specification for low-voltage switchgear and control gear
R7	IS:2705 (Part I, II, III & IV)) -2002, IEC 60044.1(1996)	Current Transformer
R8	IS:3156-2002	Voltage Transformer
R9	IS:3155-2001	Specification for Makhanna products
R10	IEC:60044.2-2006	Inductive Voltage Transformer
R11	IS:10918-2003	Specification of vented type nickel – cadmium batteries
R12	IS:722-1991-Part 1	AC Meters
R13	IS:3070-2004	Lightning Arrestor for alternating current system
R14	IS:9385(Part I to III)-2002	33 kV Drop Out Fuse
R15	IS:9920 (Part I to IV)-2001	High voltage switchyard
R16	IS:IS731-2001, IS:1248-2003 and IS:2544-2001	Insulators and Fittings
R17	IS:3231-2001, IS:722-1991 And IS1248-2003	Protection relays
R18	IS:1248-2003 and IS:722-1991	Electrical indicating instrument
R19	IS:4091-2006	Transmission lines/Poles
R20	IS: 2026-2006 and IS:7205-2006	Structural work
R21	IS:13947-2004	Low voltage switchgear

R22	IS:2121-2002	ACSR Conductor
R23	IS:1554-2005	PVC Cables
R24	IS:7098-2005	XLPE Cables
R25	IS-2099-2003	Bushings for alternating voltages above 1000V.
R26	IS-2633-2006	Methods of testing uniformity of coating of zinc coated articles.
R27	IS-335-2005	New insulating oils Electrical Clearances
R28	IS-13947-Part 1-2004	Specification for low voltage switchgear & control gear
R29	IS-3637-2001	Gas operated relays
R30	IS-3639-2001	Fittings and accessories of power transformers
R31	IS-8603-2001	Dimensions for porcelain transformer bushings for use in heavily polluted atmosphere (36 kV class)
R32	IS-5578-2006 and IS-11353-2002	Specification for marking and arrangement for switchgear, bus-bar main connection & Auxiliary wirings.
R33	IS-5578 -1970 and IS-11353-1970	Making and arrangement for switchgear Bus-bar main connections and auxiliary wiring.
R34	IS 398-2002	Aluminium conductor for overhead transmission purposes. (ACSR/ACC)
R35	IS 2121-2002	Conductor and earth wire accessories for overhead power lines.
R36	IS 4826-2006	Hot-dip galvanizing coatings on round steel wires.
R37	IS 5082-1998	Wrought Aluminium and Aluminium alloy bars, rods, tubes and section of electric purpose.
R38	IS 8130-2001	Conductor for insulated electric cable & flexible cords.
R39	IS- 4379-2002	Identification of the contents of industrial Gas cylinders
R40	IS-7285-2202	Seamless High carbon steel cylinders for permanent and high pressure liquefiable gases
R41	CBIP	CBIP Manual of Transformers-1987

### **1.3 Scope of work of technical specification**

The scope of work should begin with a general statement which outlines the various elements of the work including & wherever applicable the design, material selection, manufacture, quality assurance, quality control, shop assembly and testing, transportation and delivery to site, insurance, storage at site, installation, commissioning, field acceptance test, warrantee and other services as specified or required. The general statement should be followed by a specific detailed list of major items which the purchaser wishes to have as separate payment items in the tender form.

Detailed list of major items should be given for each equipment.

## **2.0 SWITCHYARD EQUIPMENT**

### **2.1 Vacuum Circuit Breakers**

#### **2.1.1.0 Scope**

This specification covers the manufacture, assembly; stage testing, inspection and testing before supply and delivery at site of the 12 kV, 3 Pole, 50 Hz Vacuum Circuit Breakers.

**2.1.1.1** It is not the intent to specify completely herein all the details of the design and construction of equipment. However the equipment shall conform in all respects to high standards of engineering, design and workmanship and shall be capable of performing in continuous commercial operation up to the Bidder's guarantee, in a manner acceptable to the purchaser, who will interpret the meanings of drawings and specification and shall have the power to reject any work or material which, in his judgment is not in accordance there with. The offered equipment shall be complete with all components necessary for their effective and trouble free operation. Such, components shall be deemed to be within the scope of Bidder's supply irrespective of whether those are specifically brought out in this specification and/or the commercial order or not.

**2.1.2.0 Standards**

**2.1.2.1** The materials shall conform in all respects to the relevant Indian Standard Specifications/ IEC Standards, with latest amendments.

**2.1.2.2 Conflict of Standards**

Equipment conforming to other internationally accepted standards, which ensure equal or higher quality than the standards mentioned above would also be acceptable. In case the Bidders who wish to offer material conforming to the other standards, salient points of difference between the standards adopted and the specific standards shall be clearly brought out in relevant schedule. Two copies of such standards with authentic English Translations, shall be furnished along with the offer. In case of conflict the order of precedence shall be (i) IS (ii) IEC (iii) Other standards. In case of any difference between provisions of these standards and provisions of this specification, the provisions contained in this specification shall prevail.

**2.1.3.0 Climatic Conditions**

The Vacuum Circuit Breakers to be supplied against this Specification shall be suitable for satisfactory continuous operation under the climatic conditions shown in Table 2.

**Table 2: Climatic Conditions**

<b>S. No.</b>	<b>Condition</b>	<b>Value</b>
i)	Max. ambient air temperature (deg.C)	
ii)	Min. ambient air temperature (deg.C)	
iii)	Average daily ambient air temperature (deg.C)	
iv)	Max. Relative Humidity (%)	
v)	Max. altitude above mean sea level (Meters)	
vi)	Average Annual rainfall (mm).	
vii)	Max. wind pressure(kg/sq.m.)	
viii)	Isoceraunic level (days per year)	
ix)	Seismic level (Horizontal accn.)	

The equipment shall be for use in moderately hot and humid tropical climate, conducive to rust and fungus growth.

### 2.1.4.0 Principal Parameters

2.1.4.1 Principal parameters for 11 kV Circuit Breakers are shown in Table 3.

**Table 3: Principal Parameters for 11 kV Circuit Breakers**

Parameter	Value
Service	Out door
Type	Vacuum Porcelain clad (Outdoor)
No. of Poles/Phases	Three
Rated Voltage (Nominal/Max.)	11/12kV
Rated frequency	50 Hz
System of earthing	Neutral solidly grounded
Impulse withstand Voltage	75 KVp
One minute power frequency withstand voltage	28 kV(rms)
Power frequency withstand voltage on Auxiliary circuit:	2 kV(rms)
Rated Current	630 A
Rated breaking Capacity Symmetrical	16-25 kA
Rated short time withstand current for 3 sec	16-25 kA
Rating making capacity	2.55 times Rated breaking Current
Total break time	5 Cycles(max)
Bushing Insulator creepage distance	Not less than 300mm
Mounting	Steel Structure
Operating duty for gang operation.	O-3 min-CO-3 min-CO
Operating Mechanism	Motor operated/Manual spring charged. The standard DC voltage for the operating devices shall be 24V DC. Operation Voltage for motor spring charging mechanism shall be 240 V AC single phase. Normally the breaker shall be operated by power and there shall be provision for manual operation
Terminal connector Material (for outdoor)	Suitable for ACSR DOG conductor
Limits of temperature rise	The limits of temperature rise shall be in accordance with relevant standard (IEC 62271-2012)
Requirement of simultaneity of poles	The maximum difference between instants of contact touching during closing and the maximum difference between the instant of contacts separation during opening between 3 poles shall not exceed one half cycle of the rated frequency. The breaker shall open and close simultaneously on all the three phases for fault on any phase and or on all the phases
Pad locking for both mechanism box, control panel should be provided	
All angles 65 mm X 65 mm X 6 mm minimum size for breaker structure should be provided	
Bell is operated 24 V DC	

2.1.4.2 Auxiliary Electrical equipment shall be suitable for operation on the supply system shown in Table 4.

**Table 4: Supply Systems for Auxiliaries**

Item	Value
Power devices (drive motors) and lighting	240V single phase-4 wire 50c/s. and lighting neutral grounded AC supply.
Operating DC supply	110/24VDC ungrounded 2wire
3 O/C + 1 E/F IDMT, Numerical relay auxiliary DC supply range	18 V – 235 V DC

The above supply voltage may vary as indicated in table-5 and all devices shall be suitable for continuous operation over the entire range of voltages.

**Table 5: Ranges of Voltages for Auxiliaries**

Item	Value
AC Supply	Voltage +10% to -15% : Frequency +/-5%
DC Supply	+10% to -20%.

#### 2.1.4.3 Supply Point

Auxiliary power supplies listed above will be made available to each circuit breaker as given in Table 6.

**Table 6: Details of Supply to be Made Available for Auxiliaries**

Item	Value
AC Supply	Single feeder
DC Supply	Single feeder
MCB ( Miniature Circuit Breaker)	Shall be provided at the circuit breaker for each incoming supply. For DC supply double pole MCB shall be provided ( (with different colours for easy identification).

#### 2.1.5.0 Technical Requirements

The following technical particulars are common for outdoor/Indoor VCBs except where specifically mentioned.

The equipment will be installed out door in hot, humid and tropical atmosphere. The maximum temperature in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in the relevant standards.

The equipment shall be capable of withstanding the dynamic and thermal stresses of listed short circuit current without any damage or deterioration. The safety clearances of all live parts of the equipment shall be as per relevant standards.

All equipment, accessories and wiring shall have tropical protection, involving special treatment of metal and insulation against fungus, insects and corrosion

### **2.1.5.1 Type and Duty**

The 11KV circuit breakers shall be outdoor, 3-pole, vacuum type having internal isolation without any sequential interlock.

The duty of the circuit breaker shall involve satisfactory interruption of short circuit currents as listed in principal parameters.

The breaker shall be capable of interruption of reactive current (lagging/leading) without under /over voltage

### **2.1.5.2 Constructional Features**

#### **2.1.5.2.1 General Arrangements**

The circuit breaker shall have fixed type construction consisting three single identical poles, complete with a gang operated sealed porcelain housing conforming to IP-65 protection conforming to relevant standards. All three poles of circuit breaker shall be linked together mechanically to ensure simultaneous closing of all poles.

The trip free operating mechanism, 3 phase inter connection links shall be completely accommodated in the base. There shall be sufficient clearance between live parts of the circuit breakers and the ground. The circuit breaker shall be completed with operating mechanism, other accessories/materials to ensure complete assembly and proper functioning. The current transformers shall be externally mounted on the supporting structure integrated with circuit Breaker structure. Terminal connectors suitable for ACSR DOG conductor . The circuit breaker shall be provided with proper standard earthing and with terminal earth bar for earthing connection.

#### **NOTE:**

Neither the circuit breaker nor any part of the switchgear or its supporting structures shall be permanently strained due to vibration etc., when making or breaking the rated short circuit currents.

The details of any device incorporated in the circuit breakers to limit or control the rate of restriking voltage across the circuit breaking contacts shall be stated.

The vacuum interrupter assembly used in the circuit breakers shall be interchangeable with indigenously available vacuum interrupters (make and type shall be mentioned).

#### **2.1.5.2.2 Main Contacts and Arc Quenching Chamber**

The main contacts shall have adequate area and contact pressure for carrying rated continuous and short time currents without excessive heating liable to cause pitting and welding. The tips of the arcing & main contacts shall be heavily silver plated. The contacts that are adjustable to allow for wear, shall be easily replaceable and shall have minimum moveable part and adjustments. The arc-quenching device shall be of robust construction and shall not require any critical adjustments. The devices shall be easily accessible and removable for access to the breaker contacts.

### **2.1.5.2.3 Interlock**

All electrical and mechanical interlocks, which are necessary for safe and satisfactory operation of the circuit breaker, shall be furnished. It is intended that before lockout occurs the breaker shall be in trip position.

### **2.1.5.2.4 Auxiliary Contacts**

Each breaker shall be provided with Four (4) normally open and Four (4) normally closed electrically separate spare Auxiliary contacts in addition to those required for its own operation and indication exclusively for purchaser's use.

The auxiliary contacts shall be convertible type so that normally open contacts can be converted into normally close contact and vice versa at site.

The auxiliary contacts shall be rated for 10A for AC and 5A for DC.

### **2.1.5.2.5 Insulators**

Bushing insulator for circuit Breakers shall comply wherever possible with relevant standard for High voltage porcelain bushings.

Insulators shall be wet process porcelain, brown glazed and free from all blemishes. Ferrous metal parts and hardware shall be hot-dip galvanised.

Insulator shall have adequate mechanical strength and rigidity to withstand the duty involved.

When operated at maximum system voltage there shall be no electrical discharge. Shielding rings, if necessary, shall be provided. Insulation shall be coordinated with basic impulse level of the system. The creepage distance shall correspond to heavily polluted atmosphere.

### **2.1.5.3 Operating Mechanism**

The operating mechanism shall be motor operated/ manual operated spring closing with trip free features complete with shunt trip coils. All three poles of the breaker shall operate simultaneously. It shall operate in such a way that the closing springs after each closing operation are automatically charged by the motor and locked in the charged position by a latch. Means shall be provided to charge the springs manually also. Provision shall be made for slow closing of VCB without spring charging.

The mechanism to be operated for the reclosing operations should the circuit breaker trip. The contact loading spring shall be designed in such a way that the contact bounce is eliminated and it shall be ensured and the opening stroke is commenced only from fully closed position. All the breakers shall be suitable for manual operation as well as slow closing without spring charging. Anti pumping device shall be incorporated.

Operation counter and mechanically operated indicator to show whether the circuit breaker is open or closed shall be provided on the circuit breaker operating mechanism.

All manually operating gear shall be so designed that the circuit breaker can be operated by one movement. The mechanism shall be such that the tripping spring can be charged while the circuit breaker is closed and the closing mechanism when charged shall not be operated by vibration caused by the circuit breaker opening under fault conditions. The spring shall be suitable for 4 short reclosing operations.

The mechanism shall be designed for electrical control from remote. Local manual close/trip (lever/button) shall be provided in the mechanism box.

#### **2.1.5.4 Control Cubicle (Mechanism Box) for Outdoor VCBs**

A common control cubicle shall be furnished to house electrical controls, monitoring devices and all other accessories except those, which must be located on individual poles. The cubicle shall have IP-55 of gasketed weather proof construction, fabricated from sheet steel minimum 2.5 mm thick.

The cubicle shall have front access door with lock and keys, and removable gland plate at the bottom for cable entry.

#### **2.1.5.5 Wiring & Terminal Blocks**

##### **2.2.5.5.1 Wiring**

Wiring shall be complete in all respects to ensure proper functioning of the control, protection, monitoring and interlocking schemes. Wiring shall be done with flexible 1100 V grade, PVC insulated, switchboard wires with 2.5 sq.mm stranded copper conductor, and Wiring between individual poles and control cubicle shall be routed through G.I Conduits. Each wire shall be identified at both ends with permanent markers bearing wire numbers as per wiring diagram. The wiring schematic may conform to relevant standards.

Wire termination shall be done with crimping type connectors with insulating sleeves. Wires shall be spliced between terminals.

All spare contacts of relays, push buttons auxiliary switches etc. shall be wired upto terminal blocks in the control cubicle.

##### **2.1.5.5.2 Terminal Blocks**

Terminal blocks shall be 1100 V grade, box clamp type (Stud type).

Not more than two wires shall be connected to any terminal Spare terminals equal in number to 20% active terminal shall be furnished.

Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of an external cable can be connected to constructive terminals.

#### **2.1.5.6 Name /Rating Plate**

Each circuit-breaker shall be provided with a name plate or plates legibly and indelibly marked with at least the following information:



- (i). Name of manufacturer
- (ii). Type designation and serial number
- (iii). Rated voltage and current.
- (iv). Rated frequency
- (v). Rated symmetrical breaking capacity
- (vi). Rated making capacity and
- (vii). Rated short-time current and its duration (which shall be either one or three seconds)
- (viii). P.O No. & Date and year of supply
- (ix). Guarantee of years
- (x). Operating sequence
- (xi). Make & type of vacuum interrupter
- (xii). Control supply
- (xiii). Spring charge motor voltage

**NOTE:**

- (i). The word “Rated” need not appear on the nameplate recognized abbreviations may be used to express the above quantities.
- (ii). When the circuit breaker is fitted with closing and/or tripping devices necessitating an auxiliary supply the nature of the auxiliary supply shall be stated either on the circuit breaker nameplate or in any other acceptable position.

**2.1.6.0 Tests**

**2.1.6.1** The type, acceptance and routine tests and tests during manufacture, shall be carried out on the vacuum circuit breaker as per the IEC 62271-100 -2011 (with latest revision).

**2.1.6.1.1** The standards and norms to which these tests will be carried out are listed in ISS/IEC mentioned above.

**2.1.6.1.2** For all type and acceptance tests, the acceptance values shall be the values guaranteed by the supplier in the Performa for “Guaranteed Technical Particulars” furnished in this specification or acceptance value specified in this specification, whichever is more stringent for that particular test.

**2.1.6.1.3** Test certificate of not more than three years old, from a recognized national laboratory with NABL accreditation shall be furnished.

**2.1.6.2 Type Tests**

The type tests must have been conducted on 11KV Vacuum Circuit Breakers from recognized NABL accredited test laboratories not earlier than 3 years from the date of bid opening. The bidder shall furnish two sets of type test reports as per relevant standards along with the bid. Bids without certificates of type tests will not be considered.

**2.1.6.2.1 Circuit Breakers: IS13118- 1991/ IEC62271-2011**

- (i). Temperature rise test for the main contacts.
- (ii). Measurement of resistance of the main contacts.

- (iii). Operation tests.
- (iv). Mechanical endurance tests.
- (v). Impulse voltage tests.
- (vi). One minute power frequency voltage dry withstand tests.
- (vii). One minute power frequency voltage wet withstand tests.
- (viii). Tests for short circuit conditions.
- (ix). Tests for short time current.

#### **2.1.6.2.2 Acceptance and Routine Tests**

##### **Circuit Breakers**

- (i). Measurement of resistance of the main contacts.
- (ii). Operation tests.
- (iii). One minute power frequency voltage dry withstand test on the circuit breakers.
- (iv). One minute power frequency voltage dry withstand test on auxiliary circuits.

All acceptance and routine tests stipulated in the relevant standards shall be carried out by the supplier in presence of purchaser's representative

The purchaser reserves the right to insist for witnessing the acceptance/routine testing of the bought out items to pass tests.

##### **Tests during Manufacture**

The Bidder shall furnish details of tests carried out during the process of manufacture and end inspection by the bidder to ensure the desired quality of the equipment to be supplied.

#### **2.1.6.3 Additional Tests**

**2.1.6.3.1** The purchaser reserves the right of having at his own expenses any other tests(s) of reasonable nature carried out at Bidders premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests, to satisfy himself that the material comply with the specifications.

**2.1.6.3.2** In case of failure in any type test, the supplier is required to modify the design of the material and the material shall be type tested again for the modified design, without any extra cost to the purchaser. No delivery extension shall be given for this additional testing.

**2.1.6.3.3** The entire cost of testing for the acceptance and routine tests and tests during manufacture shall be treated as included in the quoted unit price.

#### **2.1.6.4 Test Reports / Test Certificates**

**2.1.6.4.1** Record of routine test reports shall be maintained by the Bidder at his works for periodic inspection by the purchaser's representative.

**2.1.6.4.2** Test certificates of tests conducted during manufacture shall be maintained by the

Bidder. These shall be produced for verification as and when desired by the purchaser.

#### **2.1.6.5 Test Facilities**

The tests shall be carried out as per relevant Standards and test certificates shall be furnished for approval. The Bidder shall indicate the details of the equipment available with him for carrying out the various tests as per relevant Standards. The bidder shall indicate the sources of all materials. He shall indicate the name of the supplier and make of vacuum interrupters, meters, relays, conductor, insulating oil, electrical steel laminations constructional steel etc.

#### **NOTE:**

The Meters used for conducting tests shall be calibrated periodically at reputed Government Accredited Test Laboratories and test certificates shall be available at works for verification by purchaser's representative.

Tests as per applicable standards should be carried out in respect of porcelain bushings, galvanization, relays and meters.

#### **2.1.7.0 Inspection**

**2.1.7.1** The purchaser's representative shall, at all times, be entitled to have access to the works and at all places of manufacture where equipment offered shall be manufactured and the representative shall have full facilities for unrestricted inspection of the bidder's works, raw materials and process of manufacture and conducting necessary tests as detailed herein.

**2.1.7.2** The Bidder shall keep the purchaser informed in advance of the time of starting and of the progress of manufacture of the offered equipment in its various stages so that arrangements can be made for inspection.

**2.1.7.3** The supplier shall give 15 days advance intimation to enable the purchaser to depute his representative for witnessing acceptance and routine tests.

**2.1.7.4** No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off, by the purchaser in writing.

**2.1.7.5** The acceptance of any quantity of material shall in no way relieve the Bidder of any of his responsibilities for meeting all requirements of the specification, and shall not prevent subsequent rejection if such material is later found to be defective.

**2.1.7.6** Purchaser may have its option get the materials inspected stage wise by the 3<sup>rd</sup> party on each unit/units offered for inspection along with a Purchaser's representative, if it feels necessary. If a 2<sup>nd</sup> time inspection becomes necessary the inspection charges shall be borne by Bidder.

**2.1.7.7** The bidder shall indicate the name(s) of reputed inspection agencies and the inspection charges clearly for each lot. The inspection charges will be borne by the

purchaser. However the purchaser reserves the right to appoint at its cost any inspection agency to carry out the inspection.

2.1.7.8 The Purchaser reserves the right to insist for witnessing the acceptance routine testing of the bought out items.

#### **2.1.8.0 Warranty**

The period of warranty will be 5 years (five years) from the date of acceptance of the material in stores.

All similar materials or removable parts of similar equipment shall be interchangeable with each other.

#### **2.1.9.0 Mandatory Spares & Tools**

The manufacturer shall provide all necessary mandatory spares like fuses, spanners, Breaker cranking handle etc., free of cost.

#### **2.1.10.0 Guaranteed Technical Particulars**

The Bidder shall furnish the guaranteed Technical Particulars with tender.

### **2.2 SF6 Circuit Breaker**

#### **2.2.1 Scope**

Design, manufactures, transport to site, storage, erection, testing and commissioning of SF6 gas filled circuit breakers for outdoor switchyard complete with all accessories and auxiliaries required for satisfactory operation for the SHP.

#### **Detailed Scope of Supply**

Circuit breaker shall comprise three identical single pole units with specified phase-to-phase spacing. These units shall be linked together either electrically or/and pneumatically. The circuit breaker can be linked together mechanically for transformer breakers. Complete circuit breakers with all the necessary items for successful operation shall be supplied, including but not limited to the following:

- (i) Breaker assemblies with base support galvanized structures for CBs as well as for pole control cabinet, central control cabinet and foundation bolts for main structure as well as pole control cabinet and central control cabinet (except concrete foundations), terminals and operating mechanisms.
- (ii) Compressors, tanks, piping, fittings, valves and controls and necessary supports for inter-pole piping for compressed SF6 gas and for pneumatic systems.
- (iii) One central control cabinet for each breaker and one control box for each pole with all the required electrical devices mounted therein and the necessary terminal blocks for termination of cables. The necessary inter-pole cabling shall also be included in the Scope of the Contract.
- (iv) All cables ferrules, lugs, tags, etc. required for cabling from equipment control cabinet/operating mechanism to the central control cabinet of the breaker shall be supplied.

- (v) Gauges for pneumatic pressure and SF6 gas density supervision.
- (vi) All necessary parts to provide a complete and operable circuit breaker installation such as main equipment, terminals, control parts, terminal connectors and other devices whether specifically called for herein or not.
- (vii) The breaker shall be designed for high speed three pole reclosing only with an operating sequence and timing as specified.
- (viii) The assembly comprising chassis, frame-work and fixed parts of the metal casing of the breaker shall have two separate earthing terminals. The earthing terminal shall be readily accessible for maintenance and shall be marked with earthing sign.
- (ix) Connectors suitable for horizontal as well as vertical connection.

### **2.2.2 Standards**

The SF-6 gas filled circuit breakers shall comply in all respects with the requirements of the latest edition of IEC publication Nos. 60056-2008 and IS - 13118 -1991 covering up to date amendments except in so far as modified by this specification. Various parts of the circuit breakers such as supporting insulators and auxiliary equipment shall conform to relevant IEC/ISS or other internationally accepted standards whether specifically mentioned in this specification or not . For circuit breaker tanks IS- 4379-2007: Identification of the contents of industrial Gas cylinders, IS-7311-1974: Seamless High carbon steel cylinders for permanent and high pressure liquefiable gases and Indian Boiler Regulations shall also be applicable

### **2.2.3 Particulars**

The circuit breaker shall be of established design & of robust construction so as to require minimum of maintenance to provide long trouble free service & shall have ratings as given in Table 7 (as per 33 kV ,1250 Amp SF6 breaker).

The rate of rise of re-striking voltage applicable to the ratings offered shall be clearly stated in tender. Actual rupturing capacity of circuit breakers offered shall also be indicated in the tender.

### **2.2.4 Details of SF6 Circuit Breakers**

The circuit breakers to be offered shall be SF-6 gas filled type suitable for outdoor installation under the specified climatic conditions.

The circuit breakers shall ensure rapid and smooth interruption of current under all conditions completely suppressing undesirable phenomena even under the most severe and persistent short circuit conditions or when interrupting small currents including leading or lagging reactive currents.

Circuit breaker shall have a common operating device for three poles. SF6 gas conforming to IEC 60376-1993 shall be used in the interrupting units at such a pressure that the breaker does not require any complex auxiliary circuit for pressure & temperature control, special heating system and special compressors etc. Suitable gas filling and pressure monitoring arrangements (preferably independent pole wise) shall be provided.

**Table 7: Ratings of Circuit Breakers**

<b>S. No.</b>	<b>Description</b>	<b>Rating of circuit breakers</b>
(i).	Number of poles	3
(ii).	Class	Outdoor
(iii).	Rated frequency	50 c/s
(iv).	Rated voltage of breaker	33 kV
(v).	Highest System Voltage	36 kV
(vi).	Type	SF6 Gas Insulated
(vii).	Rated insulation level : a. 1.2/ 50 micro sec. lightning impulse withstand voltage for complete C.B. b. One minute dry and wet power frequency withstand voltage	170 kVp  170 kV rms
(viii).	Rated normal current at site conditions	1250 A
(ix).	Rated line charging breaking current	Not less than ..... A. corresponding switching over voltage values on line side & supply side to be intimated by the Bidder.
(x).	Rated short circuit breaking current a) rms value of AC component (rated short circuit current) b) percentage D.C. component	31.5 KA  As per IEC-60056-2008 (Latest edition )
(xi).	First pole to clear factor	1.5
(xii).	Rated transient recovery voltage for terminal faults a) corresponding to rated short circuit breaking current (Symmetrical & Asymmetrical) b) Corresponding to currents below the rated & short circuit current	As per IEC -60056-2008 (latest edition )  -do-
(xiii).	Breaking capacity under short line fault conditions with rated supply side and line side characteristics	-do-
(xiv).	Rated short circuit making current	63.5KA peak
(xv).	Operating sequence	O- 3 min-CO- 3 min- CO
(xvi).	Total break time for any current up to rated breaking current	Not more than ..... ms
(xvii).	Minimum total creepage distance phase to earth	900 mm
(xviii).	Difference in the instant of closing/opening of contacts of all the 3 pole a) Opening b) Closing	Not more than ..... ms. Not more than ..... ms.
(xix).	Small inductive current interrupting capacity	Any value up to 10A with out switching over voltage exceeding 2.0 p.u.
(xx).	Operation of breaker	Gang operation of three poles through mechanical linkages
(xxi).	Number of trip coils	Two Nos. per breaker

Insulation to earth of the circuit breaker shall be independent of SF6 pressure. Suitable measures shall be adopted in the individual interrupting units to achieve requisite degree of dryness for SF6 gas and to absorb its decomposition products. SF6 gas filling should not develop dangerous over pressures inside the interrupting units within the temperature rise limits to be encountered in service. SF6 gas filling in the interrupting units should work in the closed circuit without causing any exhaust to the open air after performing opening or closing operations. Time period in terms of number of operations on fault, number of years of normal service after which SF6 gas filling needs replacement shall be stated in the tender.

There should be no leakage of SF6 gas from the joints and sealing points. The gaskets used between the support insulators of the breakers should be such that these should not fail.

Facilities shall be provided to reduce the gas pressure within the circuit breaker to a value not exceeding 8 milibar within 4 hours or less. Each circuit breaker shall be capable of withstanding this degree of vacuum without distortion or failure of any part.

SF6 gas for first filling of each circuit breaker plus 20% extra ( to be supplied in non-returnable gas cylinders) shall be included in the scope of supply and complete specification of the SF6 gas proposed to be utilized shall be stated in the tender. Prices of SF6 gas with cylinder filling device, and trolley indicating the net weight of the gas in it must also be quoted separately.

The high pressure cylinders in which the SF6 gas shall be supplied and stored at site shall comply with the requirements of relevant standards and regulations.

Equipment for filling, evacuation and detecting leakage of SF6 gas recommended by the bidder for proper maintenance of circuit breaker shall also be offered. In case purging of breaker before filling with SF6 gas is desirable then the required equipment shall also be furnished as a part of the maintenance equipment. The plant shall be complete with necessary pipes, couplings, flexible tubes and valves for coupling to the circuit breakers.

The offer should be of latest design but of proven performance. Further the design of circuit breakers should be such that it does not become obsolete so that the normal spares are easily available even after 10-15 years of its service.

### **2.2.5 Circuit Breaker Operation**

Each circuit breaker shall be remote controlled from the control room but provision shall be made for local electrical/spring control operation also. For remote and local electrical operation, existing D.C. Supply shall be available and the power operating coils viz. Closing and Tripping coils shall be so designed that they operate the circuit breaker satisfactorily within a control voltage varying between 70% to 110% of the normal voltage for trip coils and 80% - 110% of the normal voltage for closing coils.

Each circuit breaker shall be offered with unit spring charging equipment comprising of A.C motor unit, spring, accessories, limit switches etc, along with auto recharging of the spring after each tripping. Manual arrangement for charging the spring shall also be provided.

Suitable provisions shall be made for lockout, alarm/ indicating etc. under low SF6 gas pressure conditions.

Two independent trip coils shall be provided for each breaker from reliability view point. It is intended to have continuous type of pre-closing and post –closing trip circuit supervision through auxiliary relays and suitable resistors to be connected in series with each trip coil for the purpose. All the trip coils shall therefore be designed keeping in view the above requirement.

It shall be possible to lock out the circuit breaker operating apparatus box/ switch cubicle in the open as well as closed position of the breaker.

The operating mechanism shall be trip free as per IEC-60056-2008 and shall have anti-pumping feature. A mechanical position indicator for ON/ OFF condition of the circuit breaker shall also be provided on each breaker /switch cubicle/ apparatus box in addition to electrical or pneumatic type of indications.

Mechanical indicator provided to show open and close position and operation counter shall be located in a position not more than 1.5 m. from the ground where it will be visible to a man standing on the ground level with mechanism housing closed.

### **2.2.6 Apparatus Box**

All the control equipment immediately connected with the operation of the circuit breaker shall be installed in an outdoor type, weather, vermin and splash proof strong cubicles having suitable number of hinged doors so as to afford easy access for all equipment's mounted inside. Apparatus box shall be fabricated from heavy gauge M.S. Sheet of at least 3mm thickness. Positive locking arrangement with lock (s) shall be provided on the front door to check unauthorized operation. The cubicles shall be either hot dip galvanized or of other approved design and construction so as to be suitable for use under tropical conditions at site. The cabinet shall contain the following equipment in addition to any other equipment required for satisfactory operation of the circuit breakers:

- (i). Control selector switch for local /remote electrical operation with a neutral position.
- (ii). Control switch for local electrical operation.
- (iii). Control Manual switch for local operation in the absence of DC supply.
- (iv). Separate pressure switches with alarm contacts for signalling high / low pressure of SF<sub>6</sub> gas limit switches shall also be provided for start and stop of the motors on complete spring releasing or charging.
- (v). Suitable pressure gauge (s) (Density Monitors) for showing SF<sub>6</sub> gas pressure of each limb and pressure switches for giving low gas pressure alarm and blocking of closing tripping. The contacts should be provided and wired up to terminal block getting annunciation in the control room.
- (vi). Circuit breaker mechanical ON/OFF position indicator and spring charged indication.
- (vii). Anti pumping device (Electrically operated).
- (viii). Trip coils and Closing coils
- (ix). Indicating lamps for various indications
- (x). A heating element complete with a rotary switch , thermostat
- (xi). Safety valves
- (xii). Switches and fuses for controlling AC & DC supplies
- (xiii). A power plug with switch



- (xiv). A light point with door switch
- (xv). Complete wiring for the cabinet should be fire resistant and having stranded copper conductor of cross-sectional area 2.5 mm<sup>2</sup> or more according to current requirements.
- (xvi). A terminal board with suitable number of numbered terminals including 20% spare terminals
- (xvii). Cable glands for various power and control cables
- (xviii). Emergency trip device
- (xix). Operation counter
- (xx). Rating and diagram plate in accordance with IEC incorporating the year of manufacture and purchaser's order reference.
- (xxi). Earthing terminals and lugs for the earthing of marshalling/ apparatus box
- (xxii). Any other item to complete the job

All fixtures, nuts, bolts etc. for mounting the apparatus box either on the circuit breaker supporting structure or on a nearby plinth shall be supplied by the Bidder. Apparatus box shall be equipped with requisite number of cable glands for receiving PVC insulated power and control cables necessary for the control and operation of circuit breakers.

### **2.2.7 Auxiliary Switches**

Each circuit breaker shall be provided with necessary number of auxiliary contacts both of the normally open and normally closed type for satisfactory operation of the breaker and for operating ON/OFF indication lamps locally and semaphore indicators on the control panel. In addition 10 nos., normally open and 10 nos. normally close contacts shall also be provided with each circuit breaker as spare for various interlocking, schemes and remote position indications. It shall be possible to change any number of normally closed contacts into normally open contacts and vice versa. The total number of auxiliary contacts thus provided and the rating of each contact shall be clearly stated. There shall be a provision to add more auxiliary contacts at a later stage. The leads from auxiliary contacts shall be brought to a terminal board installed inside the auxiliary contact housing and suitable cable glands shall be provided for terminating PVC insulated control cables.

### **2.2.8 Mountings**

The circuit breakers shall be self supporting type. However, if necessary for the purpose of minimum ground clearance the circuit breakers shall be mounted on raised steel structures which shall be included in the scope of supply. The successful Bidder shall supply the following information and data for design of foundations after the award of the contract.

- (i). Dead weight per pole and for complete circuit breaker
- (ii). Static bending moments about the foot of each pole and for complete circuit breaker.
- (iii). Static shear force at the foot of each pole and for complete circuit breaker
- (iv). Maximum height of the steel supporting structure
- (v). Maximum diameter of the pole
- (vi). Maximum horizontal force acting at upper terminal of each pole due to impact of closing/opening of the circuit breaker

- (vii). Max. impact loading in terms of equivalent static load both compression and upward due to opening/closing of the breakers. It shall be clearly stated whether these forces shall act simultaneously or at different timing.
- (viii). No. of steel supporting columns provided for mounting the equipment.
- (ix). Foundation plan suitable for breaker structures.

The above data shall represent static reactions for the worst windage or operation conditions. Circuit breakers whether of self supporting type or on raised steel structure shall ensure minimum sectional clearance required as per relevant ISS for the selected voltage level.

Necessary connecting materials such as clamps, bolts, nuts, washers etc. and fixing bolts for mounting the equipment on the supporting structures and foundation bolts shall also be supplied by the Contractor.

### **2.2.9 Design Features**

#### **(i) Contact System**

The design of contact system of the circuit breakers shall be such as to provide easy access to the contact system while undertaking maintenance and replacement jobs.

Auxiliary arcing contacts may be provided to protect the main contacts from damage during circuit breaker operation.

Main contacts shall be silver plated and the thickness of silver plating shall be stated in the tender. Material of main & arcing contacts shall also be stated in the tender.

It may clearly be stated whether the contact travel is sufficient to withstand the rated voltage of the breaker in the event of leakage of SF6 gas from the poles.

In the event of leakage of extinguishing medium to a value which cannot withstand dielectric stresses specified in the open condition, it may be clearly stated whether the contacts will remain in the open condition or self close.

Main contacts shall have an ample area and contact pressure for carrying the rated current and short time rated current without excessive temperature rise which may cause pitting or welding. Material and cross section area of the main contacts shall clearly be stated in the tender.

Main contacts shall be the first to open and last to close so that contact burning and wear are the least.

#### **(ii) Temperature Rise**

The maximum temperature and temperature rise attained by various parts of the circuit breaker when in service at site under continuous full load conditions and exposed continuously to the air and direct rays of the sun shall not exceed the permissible limits specified in IEC-60056-2008 (latest edition) or relevant ISS.

**(iii) Recovery Voltage and Power Factor**

Each circuit breaker shall be capable of interrupting without opening resistors rated power with recovery voltage corresponding to the rated maximum line to line service voltage at rated frequency and at a power factor not exceeding 0.15. The breakers shall also be capable of interrupting faults currents of magnitude 2 to 10% of rated breaking current without causing any re-strike or non permissible over voltage in the system, critical current which gives the longest arc duration at lock out pressure of extinguishing medium and arc duration shall be indicated in the tender.

**(vi) Asynchronous Operation**

Each circuit breaker shall be capable of satisfactory operation even under conditions of phase opposition which may arise due to faulty synchronism as per IEC-60056-2008 requirements. The maximum current which the circuit breaker can satisfactorily interrupt at twice the maximum phase to ground applied voltage under phase opposition conditions shall be stated in the tender.

**(v) Transformer Charging Current Breaking Capacity**

The circuit breakers shall be capable of interrupting small inductive currents such as those occurring while switching off unloaded transformer banks and reactor/ capacitor loaded transformers without giving rise to undue over voltage and without re-strikes. The minimum transformer charging current which can be interrupted by the breaker and corresponding over voltage value under such conditions shall be stated in the tender

**(vi) Restricting Voltage**

The circuit breakers offered shall be re-striking free. The rated transient recovery voltage (TRV) for terminal faults shall have specified values. Measures adopted for ensuring proper operation at high rate of rise of re-striking voltage (RR) and for limiting actual voltage across the circuit voltages breaker shall be described. The details of any device incorporated to limit or control the rate of rise of re-striking voltages across the circuit breaker contacts shall also be stated. The circuit breaker shall be capable of withstanding higher peak voltage and RR of TRV expected during clearance of short circuit immediately after the power transformers in the vicinity of centre of generation and at the end of long lines.

**(vii) Overhead Line Charging Current Interrupting Capacity**

Each circuit breaker shall be designed so as to interrupt without restricting the assigned line charging current as per IEC publication No. 60056-2008(latest edition) , if any , corresponding assigned maximum over voltages both on the line and supply side of the circuit breaker shall be clearly stated.

**(viii) Breaking Capacity for Kilometric Faults**

The interrupting capacity of the circuit breaker for kilometric faults under supply side and line side characteristics shall be as per IEC –60056-2008. The details of test conducted from providing the capabilities of the breakers under kilometric fault conditions shall also be stated in the tender.

## **(ix) Insulating Supports**

The porcelain used for bushing/support insulators shall be homogenous, free from cavities and other flaws. The bushings shall be securely cemented with the pole base such that its failure to base due to shear is minimum. The insulators shall be designed to have ample insulation, mechanical strength and rigidity for satisfactory operation under the conditions indicated in this specification. All insulators / bushings of identical ratings shall be interchangeable. The puncture strength of insulators/bushings shall be greater than the flash – over value. The insulators/bushings shall be entirely free from ratio disturbance when operating at voltage 10% above rated voltage and shall also be free from external and internal corona. Total phase to earth creepage distance and that between top and bottom terminals shall not be less than the specified values.

### **2.2.10 Noise Level**

The circuit breakers shall be reasonably quiet in operation. Noise level at the base of the breaker should be less than 140dB. Breakers shall be provided with sound muffles to reduce the noise level, if required. Bidders shall indicate the noise level of breaker at distance of 50, 100 and 150 m from itself.

### **2.2.11 Terminal Connectors**

Circuit breakers shall be provided with appropriate number of solder less clamp type Aluminium / Bimetallic connectors which shall be universal type suitable for horizontal as well as vertical takeoff with single conductor as per actual requirement. Short circuit rating and time as well as continuous current rating of the terminal connectors shall be the same as that of the circuit breaker offered.

### **2.2.12 Grounding**

Two grounding terminals shall also be provided on each equipment / apparatus for proper grounding connection with the station ground-mat.

### **2.2.13 Metal Parts**

All ferrous parts of equipment shall be heavily hot dip galvanized. Bolts, nuts, screws, pins, washers etc. used in these equipment shall also be galvanized. The galvanizing should conform to IS 2629-2006 – latest edition.

All current carrying parts shall be of non-ferrous metal or alloys and shall be designed to limit sharp points, edges and sharp faces.

### **2.2.14 Tests**

#### **(a) Type Tests**

The circuit breaker alongwith its operating mechanism shall conform to the requirement of type tests as per latest edition of, IEC 60056-2008 /IEC: 60694- 1996/IS :13118-1991.

Complete set of type test reports with necessary oscillograms, drawings pertaining to the offered circuit breakers shall be submitted with the tender. Tenders not accompanied by Type Test Reports as specified in IEC –60056-2008, shall not be considered. Type test carried out by reputed test laboratory only shall be acceptable.

**(b) Routine tests**

The routine tests as per latest edition of IEC publication No. 60056-2008, IEC – 60694-1996 or IS –13118-1991 covering up to the date amendments shall be carried out in the presence of purchaser’s representative.

Routine test certificates of associated equipment such as motors support insulators, hollow insulators ,gas cylinders and SF6 gas etc as per relevant IS/IEC shall also be supplied for reference and record of the purchaser.

**(c) Field Tests of Breakers**

Each circuit breaker shall be liable to undergo field testing before its initial operation. During the field testing, each circuit breaker must satisfactorily perform and satisfy the requirements of the specification. Special tests, if any, arranged by the purchaser at site to prove any of the requirement of the breaker shall be carried out in the presence of supplier’s Engineers who shall fully associate with the testing.

Details of the pre-commissioning tests to be carried out on the breakers at site shall be enclosed with the tender for reference and approval of the purchaser.

Special tools and tackles required, if any, for the pre-commissioning tests shall also be clearly indicated in the tender.

All test reports for routine tests shall be submitted and got approved from the purchaser before dispatch of the equipment.

**2.2.15 Guaranteed Technical Particulars**

Guaranteed technical particulars as per provision of Tender Document shall be furnished along with the tender.

**2.2.16 Spare Parts**

The bidder shall quote for the mandatory spares and recommended spares as per requirement for 5 years of free service. Purchases shall furnish a list of such spares with the Tender document.

**2.2.17 Erection Tools**

The Bidder shall separately quote for sets of tools required for initial erection and subsequent maintenance of the circuit breakers. Description of tools along with their item wise prices included in the set shall be clearly stated.

**2.2.18 Drawings Literature and Manuals**

As soon as possible but not later than 30 days of the award of contract, the successful bidder shall submit for approval four copies of drawings showing general arrangement

outlines dimensions, wiring and schematic drawings of the equipment. The purchaser shall convey his approval / comments within one month.

The supplier shall supply 8(eight) sets of final drawings along with one set of reproducible there of and eight sets of operating and maintenance instructions manual for the equipment before the actual dispatch of equipment along with a soft copy of both.

#### **2.2.19 Instruction Plates and Markings**

All name plates, instruction plates, wiring signs and any marking or word on the equipment and its parts and accessories should be in English language.

In order to facilitate sorting and erection at site, every part of the plant and equipment shall be suitably marked. These markings shall be in conformity with those given on the assembly drawings.

All name plates shall be riveted one. The main nameplate shall also be riveted inside the apparatus/ switch cubicle. P.O. No. & name of purchaser shall be mentioned on the name plate drawings,

#### **2.2.20 Completeness of Equipment**

Any fittings, accessories or apparatus which may not have been specifically mentioned but are usually necessary for the satisfactory operation of the equipment shall be deemed to have been included in this specification. All foundation bolts shall be included in the scope of supply. Earthquakes dampers if necessary shall also be provided on the equipment without any extra cost.

#### **2.2.21 Bill of Material**

The drawings for the bill of material of the breaker must accompany the tender. It will consist of separate drawings with elevations, plans, top views and cross sections of all main parts of the breaker. The parts/items to be sent loose shall also be shown/mentioned in the bill of material drawing. On receipt of equipment at site, the consignee shall compare it with the bill of material mentioned/ shown on the bill of material drawings in order to find out the material/items supplied short /damaged by the supplier with a particular consignment. In case some items other than those mentioned in the bill of material drawings are found short/defective at the time of commissioning of breaker, the same shall be considered to have been supplied short/defective at the time of receipt of material. As such the supplier must mention/shown all the main items of the breaker on the bill of material drawing, which are liable to be dispatched and must be checked by the consignee at the time of receipt of equipment at site.

### **2.3 Current Transformers**

#### **2.3.1 Scope of Supply**

The scope of supply shall include the CTs as per Table 8 complete with terminal connectors, junction boxes etc.

**Table 8: Table for Scope of supply**

Purpose	No. of CTs	No of cores	Class of Accuracy	Ratio	Knee point Voltage	ALF/ kLF
<b>Transformer bays (..... No.)</b>						
Protection	.....	4	PS	---/1-1-1-1	To be specified by the bidder	
Protection			5P			15
Metering			0.2			< 5
<b>Feeder bays (..... Nos.)</b>						
Protection	.....	4	PS	---/1-1-1-1	To be specified by the bidder	
Protection			5P			15
Metering			0.2			< 5

The knee point voltage and other parameters shall be so selected that all the CTs shall be interchangeable.

**2.3.2 Basic Ratings of CTs** are given in Table 9.

**Table 9: Basic Ratings of CTs**

Rating	Value
Rated voltage	36 kV
Power frequency withstand voltage for one minute	75 kV
Insulation level	170 kV (peak)
Rated secondary current	1 A
Short time current rating for 1 sec	To be specified by the Purchaser
Rated dynamic current	To be specified by the Purchaser
Maximum temperature rise over design ambient temperature	As per IEC: 60185
One minute power frequency withstand voltage between secondary terminal & earth	2.5 kV

Other details of the technical requirements shall be calculated by the bidder.

### 2.3.3 Performance Criteria

- (i). The current transformer characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 10% to 100% of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of protection CTs.
- (ii). For measuring CT's the instrument security factor (ISF) at all ratios shall be less than five (5).
- (iii). The temperature rise of current transformer winding when carrying rated current at rated frequency with rated output shall conform to the IS 2705 (Part 1) : 1992

- (iv). The cores used for protection shall produce undistorted secondary current under transient conditions at all ratios, with specified CT parameters

### **2.3.4 Constructional Features (Live Tank type CTs shall be preferred)**

#### **2.3.4.1 Primary Winding**

The conducting material for the primary winding shall be of electrolytic high conductivity copper strips and sufficient area of cross section shall be provided to cater for the guaranteed short time as well as continuous thermal current ratings under site conditions. The winding shall be of wound type or hair pin type.

The main insulation shall be paper and oil combination having high mechanical strength, superior electrical withstand properties and good ageing qualities to ensure long trouble free life for the CTs. Winding shall be designed to have high mechanical strength for safety against short circuit stresses.

#### **2.3.4.2 Secondary Winding**

The secondary winding shall be high conductivity copper wire of suitable cross-section. The copper wires shall have enamel insulation and paper insulation may also be provided to enhance reliability. The secondary winding shall be uniformly distributed on the total circumference of the core. For obtaining different ratios, the secondary winding may be suitably tapped. The leads of the secondary taps shall be brought out to the terminal box. In addition to above the manufacturer shall meet the following requirements:

- (i). The secondary winding shall be totally encased in metallic shielding providing a uniform equi-potential surface for even electric field distribution.
- (ii). The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.
- (iii). The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.
- (iv). Nitrogen if used for hermetic sealing should not come in direct contact with oil.
- (v). The secondary terminals shall be terminated to stud type non disconnecting terminal block inside the terminal box.

#### **2.3.4.3 Core**

All the cores may be continuous without any air gap. All the protection cores shall be formed out of high grade, cold rolled, grain – oriented silicon laminated steel, whereas the metering cores in which high accuracy at low amperes turns and low ISF are required, may be of Mu metal or such other ferromagnetic material. The core material shall have low hysteresis loss and high permeability. The area of cross-section of the cores as also the flux densities at rated primary current and rated burden shall be consistent with the required characteristics of the CTs. The cores shall be carefully annealed and bonded after they are wound to relieve the stress during winding.



- (i). Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short-circuiting and grounding of CT secondary terminals.
- (ii). Current transformers shall be hermetically sealed units.
- (iii). Polarity marks shall indelibly be marked on each current transformer and at the lead terminals at the associated terminal block.
- (iv). Bushings/insulators shall conform to relevant clause of IS. The bushing/insulator for CT shall be one piece without any metallic flange joint. Bushings shall be provided with oil filling and drain plugs, oil sight glass etc. The bushing/insulator of current transformer shall have adequate cantilever strength.

### **2.3.5 Fittings and Accessories**

The contractor shall provide all the fittings, accessories and auxiliaries to be provided as per requirements of the equipment. They shall include but not limited to following:

- (i). Terminal Connectors
- (ii). Main Auxiliaries

The name plate shall contain the information as per relevant Indian Standard and IEC. However it shall contain but not limited to following information:

- (i). Manufacturer Name & country of origin
- (ii). Year of Manufacturer
- (iii). Serial Number & type
- (iv). Rated primary & secondary currents
- (v). Rated frequency
- (vi). Rated VA & Accuracy Class
- (vii). Rated KLF/ISF
- (viii). Knee point voltage
- (ix). Highest system voltage
- (x). Rated insulation level
- (xi). Rated short time thermal current
- (xii). Rated dynamic current

## **2.4 Voltage Transformers**

### **2.4.1 Detail Scope of Supply**

The supply of Voltage Transformers complete in all respects with terminal connectors, junction boxes etc. for the purpose of synchronization, protection and metering.

**2.4.2. Basic Ratings of voltage transformers** are given in Table 10.

### **2.4.3 Fittings & Accessories**

Fittings, accessories and auxiliaries to be provided as per requirements of the equipment of ..... kV VTs. Junction boxes (3 phase) shall be equipped with 5 Amps. 110 volts AC triple pole miniature circuit breakers, continuously rated with one set of normally closed and one set of normally open auxiliary contacts.

**Table 10: Basic Ratings of Voltage Transformers**

<b>S. No.</b>	<b>Particulars</b>	<b>Values</b>
(i).	Type	Outdoor
(ii).	Rated Primary Voltage	..... kV
(iii).	Number of Secondary Windings	Two
(iv).	Rated Secondary Voltage	
(v).	Winding-I	----- volts
(vi).	Winding-II	----- volts
(vii).	Rated Burden	- ----
(viii).	Winding-I	To be specified by the Purchaser
(ix).	Winding-II	To be specified by the Purchaser
(x).	Accuracy class	
(xi).	Winding-I up to 110% burden	- do -
(xii).	Winding-II	- do -
(xiii).	Voltage Factor	
(xiv).	Continuous	- do -
(xv).	For 30 seconds	- do -
(xvi).	One minute power frequency withstand test voltage	75kV rms. (for 33 kV system)
(xvii).	1.2/50 microsecond impulse wave withstand test voltage	170 kV(peak) (for 33 kV system)
(xviii).	One-minute power frequency withstand voltage on secondary winding.	2.5kV (for 33 kV system)

## **2.5 Surge Arrester**

### **2.5.1 Scope of Supply**

The scope of supply shall include suitable no, of Zinc Oxide surge arresters for step-up transformers and transmission line.

Each Surge Arresters shall be complete with all fittings and accessories including Current indicating meter with push buttons to indicate the leakage current, Surge Counters and Pressure relief device.

**2.5.2 Basic Ratings of Surge Arrestors** are given in Table 11.

## **2.6 Isolators and Earthing Switch**

### **2.6.1 Scope of Supply**

The supply of this section shall include

- (i) Horizontal blade, single/double break... kV, motor driven bus bar isolators to be operated as complete set for three-phase operation with electrical and mechanical interlocks.
- (ii) Horizontal blade, single/double break, ..... kV, motor driven line isolator to be operated as complete set for three-phase operation, electrical and mechanical interlocks with earthing switch.

**Table 11: Basic Ratings of Surge Arrestors**

Particulars	Values
Rated Voltage	30kV (for 33 kV System)
Nominal Discharge Current	10 kA (for 33 kV System)
Rated Frequency	50 Hz
Power frequency spark over voltage	45kV rms (for 33 kV System)
Maximum impulse spark over voltage	108kV peak (for 33 kV System)
Lightening impulse residual voltage	108kV peak (for 33 kV System)
Front-of-wave impulse voltage	125kV peak (for 33 kV System)
Wave shape of discharge current	8/20 micro second
High current impulse withstand value	100 kA (for 33 kV System)
Total Creepage Distance	900mm (for 33 kV System)
Pressure relief class	A
Current for pressure relief test	31.5 kA (for 33 kV System)

**2.6.2 Basic Ratings of Isolators** are given in Table 12.

**Table 12: Basic Ratings of isolators**

S. No.	Particulars	Values
(i).	No. of poles	3
(ii).	Rated frequency	50 Hz
(iii).	Rated Continuous Current	To be specified by the Purchaser
(iv).	Rated short time withstand current	To be specified by the Purchaser
(v).	Rated dynamic short circuits withstand current of isolators and earth switch.	To be specified by the Purchaser
(vi).	Rated short circuit making current	To be specified by the Purchaser
(vii).	Type of break	Horizontal
viii.	Basic insulation Level	
(ix).	Full wave impulse withstand voltage between line terminals and ground	170kV (for 33 kV System)
(x).	One minute power Frequency withstand voltage between line terminals and Ground	75kV (for 33 kV System)
(xi).	Creepage distance	900 mm (for 33 kV System)
(xii).	Manual Operation	Local driving linkage mechanism
xiii.	Interlock	Electrical/ Mechanical
xiv.	Maximum temperature rise of current carrying parts	As per IS 9921
(xv).	Rating of auxiliary contacts	10A at 110V DC

### 2.6.3 Earth Switches

- (i). The earth switches shall form an integral part of line isolators and shall be mounted on the base frame of the isolator.
- (ii). Earth switches shall be only locally operated.

- (iii). The earth switches shall be constructionally interlocked with the isolator so that the earth switches can be closed only when the isolator is open. 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.

## **2.7 Horn Gap Type Fuse Set**

Horn Gap type fuse set is intended for protection of Station Auxiliary transformers. The fuse set shall conform to relevant Indian/ International Standards. Necessary structures and post insulators shall conform to relevant Indian/ International Standard and shall be supplied as per requirement. The Current carrying capacity shall be kept adequate and short time current carrying capacity shall be kept equal to the highest fault current on the system to carry for 3 seconds.

## **2.8 Applicable Standards**

Equipments under this section shall conform to latest edition of relevant Indian Standards.

Equipment complying with other internationally accepted standards such IEC, BS, USA, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case the Bidder shall clearly indicate the standards adopted, furnish a copy in English of the standards adopted, furnish a copy in English of the latest revision of standard along with copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison. A list of Indian Standards is enclosed as Annexure I.

## **3.0 GENERATOR TRANSFORMERS**

### **3.1 Scope of Supply**

The supply of Generator Transformers shall include:

- (i). Requirement in nos., capacity in kVA/MVA and voltage ratio to be given. These should be oil-filled step-up transformers complete with all necessary items such as bushings, undercarriage, off-load tap changer, neutral CT's, radiators, instrumentation, marshalling boxes, fittings, insulating oil for first filling (with 20% extra quantity) etc.
- (ii). Oil Spill collection to cater oil spillage following fire or due to other reasons.
- (iii). Items not specified above but necessary for completion and satisfactory operation of the transformers.

### **3.2 Basic Ratings**

Basic ratings of Generator Transformer should be given as per Table 13.

### 3.2.1 Continuous rating at maximum ambient temp

**Table 13: Basic ratings of Generator Transformer Continuous rating at max Ambient Temperature**

Description	Ratings
<b>kVA Rating</b>	..... kVA
Voltage ratio	Primary/Secondary voltage in kV
Frequency of the system	50 Hz $\pm$ 5%
Installation	Outdoor
Type of winding	Interleaved disc winding
Class of Insulation	A
Rated voltage of -H.V. winding -L.V. winding	..... kV ..... kV
Max. Operating line voltage -H.V. -L.V.	..... kV ..... kV
Type of cooling	ONAN/ONAF etc.
System earthing	
(i) H.V. winding	..... kV side: Generator neutral terminal grounded through grounding resistor
(ii) L.V. winding	..... kV side: Effectively earthed Star (neutral point earthed through neutral C.T Delta (directly connected to generator terminals through ..... kV XLPE cable.
(iii) Neutral bushing (..... kV)	It shall be solidly grounded through separately mounted 2 core current transformer
Vector group	y n D11
Tap changer	
(i) Type	Off- load
(ii) Range	From -5% to +5% in steps of 2.5%
(iii)Steps	Each of 2.5%
(iv) Location	H.V. side
Impedance at rated MVA and rated frequency	To be specified by the bidder (should be same for both the transformers)

### 3.2.2 Insulation Level

#### 3.2.2.1 Winding of Transformer

Ratings of generator transformer windings should be mentioned as per Table 14.

**Table 14 : Specification of Generator Transformer Windings**

<b>(a) Rated short duration power frequency withstand voltage</b>	
- H.V. winding	..... kV
- L.V. winding	..... kV (rms)
- H.V. neutral	..... kV (rms)
<b>(b) Lightning impulse withstand voltage</b>	
- H.V. winding	..... kV (peak)
- L.V. winding	..... kV (peak)

### 3.2.2.2 Bushings

Specification of bushing should be given in Table 15.

**Table 15: Specification of Bushings**

Particular	Values
<b>(a) Type of Bushings :</b>	
- H.V.	Porcelain
- L.V.	Porcelain
- H.V. neutral	Porcelain
<b>(b) Rated voltage</b>	
- H.V. Bushing	..... kV
- L.V. Bushing	..... kV
- H.V. neutral Bushing	..... kV
<b>(c) Short Duration Power frequency withstand voltage</b>	
- H.V. Bushing	..... kV (rms)
- L.V. Bushing	..... kV (rms)
- H.V. neutral Bushing	..... kV (rms)
<b>(d) Lightning impulse withstand voltage</b>	
- H.V. Bushing	..... kV (peak)
- L.V. Bushing	..... kV (peak)
- H.V. neutral Bushing	..... kV (peak)
<b>(f) Minimum creepage distance</b>	
- HV bushing	..... mm
- LV bushing	..... mm
- Neutral bushing	..... mm

### 3.2.2.3 Other Features

Other features should be given in Table 16.

## 3.3 Evaluation of Losses

- (i) Capitalization of Losses
  - (a) For the purpose of cost evaluation following standard rates for capitalization of the losses will be used.
  - (b) Iron loss : Rs. .... per KW (To be specified by Purchaser)
  - (c) Copper loss : Rs. .... per KW (To be specified by Purchaser)
  - (d) The fixed losses shall be as low as is consistent with the modern design technique, reliability and economical use of material.
  - (e) The no load loss in kilowatts at rated voltage & frequency and load losses & total loss in kilowatts at rated output, voltage & frequency shall be guaranteed under penalty for transformer. For the purpose of penalty computations the tests figures of the no load and total losses will be compared with the corresponding guaranteed figures and penalty shall be imposed as given above.
  - (f) The penalties shall be separately evaluated from:
  - (g) The excess of the test figures of the no load loss in kW over the corresponding guaranteed value.
  - (h) Excess of the difference between the test values of the total loss and no load loss in kW over the differences of the corresponding guaranteed value

**Table 16: Other Features**

<b>Particular</b>	<b>Values</b>
a. Maximum flux density at normal voltage, frequency and normal ratio	.....Tesla
Voltage withstand capacity during sudden disconnection of load	
- 1.4 times the rated voltage	For 5 seconds
- 1.25 times the rated voltage	For 1 minute
- 1.1 times the rated voltage	Continuous
Max. temperature rise with reference to maximum ambient temperature of 45°C	
i. Temperature rise of top oil measured by thermometer	50 <sup>0</sup> C
ii. Temp. rise of winding measured by resistance	60 <sup>0</sup> C
Noise level	As per IS
Overload Capacity	10 %
Short circuit withstand capacity	..... kA for 1 second
Insulation	
i. HV winding	Class A Graded (winding insulation shall be able to withstand .....kV continuously)
ii. LV winding	Class A Fully insulated
h. Partial discharge level (at voltage $1.5 U_n/\sqrt{3}$ )	< ..... pc

## (ii) Evaluation of bid

The figures of these losses given by the Bidders shall be compared and price adjustment for Bid Evaluation shall be calculated at the rates given above. Fractional difference shall be loaded at pro rata basis.

**3.4 Special Features****3.4.1 Core**

- (i). The core shall be boltless. It shall be elaborated in the bid the different methods of making the core boltless along with merits and demerits of such methods.
- (ii). The core should be so designed that the working flux density does not exceed 1.57 Tesla at normal voltage, frequency and ratio.
- (iii). The tenderers shall indicate the maximum flux density allowable continuously, as well as for the time intervals of 1 minute and 5 Sec. They shall also indicate the limit of flux density at which core material used by them saturates.
- (iv). The above flux density has been specified to meet with the over fluxing of the core due to temporary over voltage of the order of 31% for 1minute, 44% for 5Sec. that may appear in abnormal conditions such as those following sudden loss of large loads/ tripping of generator breaker.

Flux density should not exceed  $1.9 \text{ Wb} / \text{m}^2$  at any tap position.

### **3.4.2 Windings**

- (i). Design, arrangement, insulation and assembly of winding on core shall be such as to ensure uniform distribution of voltages amongst all coils and minimize strains in winding due to terminal short circuit. No corona discharge shall result in winding upon exciting transformer for specified induced voltage test.
- (ii). Magnitude of impulse surges transferred from HV to LV winding by inductive and capacitive coupling shall be limited to basic insulation level (BIL) of LV winding. Expected value of switching surge withstand strength of proposed arrangement shall be mentioned in the bid document. Inter-phase barriers shall be provided. Details of inter-winding insulation and inter-phase barriers proposed should be described and illustrated by drawings or pamphlets furnished with the bid document.
- (iii). Method devised to develop impulse withstand strength shall be described in the bid document along with copies of any oscillographic type test made on similarly wound transformers of equal or higher voltage class.

### **3.5 Bushings & Termination Arrangements**

#### **3.5.1 Bushings**

- (i). Bushings shall be wet process porcelain with uniformly brown external shell. All bushings shall be designed or equipped to withstand arcing or flashover without damage to seals or any vital part.
- (ii). The Electrical characteristics of bushings shall be in accordance with relevant IEC standards / IS: 2099. Any stress shield shall be considered as an integral part of bushing assembly.

#### **3.5.2 HV and LV Terminations**

- (i). H.V Terminations

HV line terminals shall be brought out through ..... kV class weather proof, shaded, porcelain bushing for ..... kV transformer having adequate current carrying capacity (to be specified) with minimum creepage distance of ..... mm. Terminal connector shall be suitable for connecting suitable ACSR conductor.

- (ii). L.V Terminations

L.V. line terminals shall be brought out through ..... kV class, weather proof, shaded, porcelain bushings with a minimum creepage distance of ..... mm (current carrying capacity to be specified). The arrangement to be provided for connection of LV bushings of these transformers to the ..... kV XLPE cable shall be elaborated in the bid for approval of the Employer.

- (iii). Neutral Terminations

HV neutral terminal shall be brought out through ..... kV class, outdoor, weather proof, shaded, oil filled bushing with minimum creepage distance of ..... mm. This terminal shall be brought down to the base of transformer by copper strip supported on the suitable insulators on the side of transformer. Copper strip at the end shall have



two (2) neutral grounding terminals each complete with bolt, nut, plain & spring washers suitable for connecting earthing strips. Current carrying capacity shall be equal to that of HV bushing. The neutral shall be solidly connected to the grounding system (which shall be different from the main grounding system) through neutral current transformers.

(iv). Neutral CT

One (1) ..... kV two core HV neutral current transformer with following particulars for restricted earth fault and stand by earth fault protections shall be provided. Separate mounting arrangement for neutral current transformer shall be made on the transformer tank.

Core-1 for restricted earth fault  
Core -2 for stand by earth fault

Technical Particulars:

(i)	Ratio	..... /1-1-1-1
(ii)	Accuracy Class	
	(a)Protection	PS...P.....
	(b)Metering	0.2; ALF <5
(iii)	Output	..... VA
(iv)	Secondary Resistance	< 1 $\Omega$
(v)	Knee point voltage	..... Volts
(vi)	Short Time Current Rating	
	(a)One (1) second	..... KA
	(b)Dynamic Current Rating	..... KA

### 3.6 Internal Earthing Arrangement

#### (a) Earthing of Core Clamping Structure

The top main core clamping structure shall be connected to the tank body by a copper strap. The bottom clamping structure shall be earthed by one or more of the following methods:

- (i) By connection through vertical tie rods to the top structure.
- (ii) By direct metal-to-metal contact with the tank base maintained by the weight of the core and windings.
- (iii) By a connection to the top structure on the same side of the core as the main earth connection to the tank.

#### (b) Earthing of Magnetic Circuit

The magnetic circuit shall be earthed to the clamping structure at one point only, through a link placed in an accessible position beneath an inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection.

Magnetic circuits having an insulated sectional construction shall be provided with a separate link for each individual section. Where oil ducts or insulating barriers parallel to the plane of the lamination divide the magnetic circuit into two or more electrically separate parts, the ducts of barrage shall be bridged by tinned copper strip bridging pieces to maintain electrical continuity and the magnetic circuit shall not be regarded as being of sectional construction.

**(c) Earthing Terminal**

Two earthing terminals capable of carrying for three second the full load earth fault current of the transformer shall be provided. Provision shall be made at position close to each of bottom two corners of the tank for bolting the earthing terminals to the tank to suit the local conditions. Suitable earthing terminals for connection of bus duct earthing system shall also be made.

**(d) Earthing of Coil Clamping Rings**

Where coil clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of transformer as the main earth connections.

**3.7 Tap Changing Equipment**

Details of off-load tap changing mechanism shall be elaborated in the bid document.

**3.8 Fittings and Accessories**

Each transformer shall be provided with all standard accessories including the following:

- (i). One 150 mm (6") dial type indicating thermometer (OTI) of robust pattern mounted on the side of the transformer at a convenient height to read the temperature in the hottest part of oil and fitted with alarm and trip contacts.
- (ii). 1 No., 150 mm dial type winding hot spot temperature indicator (WTI) placed in HV/LV winding, as described below:
- (iii). It shall be indicating type responsive to the combination of top oil temperature and winding current calibrated to follow the hottest spot temperature of transformer winding. The device shall have a additional pointer to register the highest temperature reached. Winding temperature indicator should have two sets of contacts. Contacts of the WTI shall be used for trip and alarm purpose, wiring of which will go to the main control and relay panel of the transformer (external control cables from the Marshalling kiosk to the Control & Relay panel are covered in separate section.)
- (iv). One explosion vent on transformer tank cover.
- (v). Inspection covers with jacking bolts in the top cover plates of the tank.
- (vi). One filter - cum - oil drain valve with plug or blanking flange size 80mm.
- (vii). One filter valve at top of transformer tank size 50mm.
- (viii). One double float gas/oil surge detecting (Buchholz) relay in the pipe connecting the conservator with tank, complete with alarm/tripping contacts to detect accumulation of gas and sudden rise of oil pressure, complete with two shut - off valves on

conservator side as well as tank side and a coupling to permit easy removal without lowering flanges/oil level in the main tank. The size of shut - off valve shall be 80mm.

- (ix). Two grounding terminals on breadth side of tank.
- (x). Skids and pulling eyes on both sides.
- (xi). One Marshalling box housing dial type thermometers for winding and oil temperature indicators.
- (xii). Thermometer pockets for mercury in glass thermometer of minimum 25 cm depth from top level.
- (xiii). A set of universal type bi-metallic multi-bolt double grooved conductor clamps for HV side capable of receiving single ACSR conductor for bushing of 33 kV side of transformer.
- (xiv). Suitable bi-metallic flexible connectors for neutral terminals.
- (xv). One set of terminal bushings each for HV & LV winding.
- (xvi). One set of Neutral bushing (s) with ring type CT of appropriate ratio, PS/ 5P10 30A for earth fault protection.
- (xvii). Suitable size bi-directions wheels for rail gauge to suit existing tracks in both directions-4 Nos. along with locking and bolting devices.
- (xviii). The following plates, marked in English, shall be fixed to the transformer tank at about 1750mm above ground level:
  - (a) Rating plate bearing date as specified in IS: 2026-2006, it must contain insulation levels of various windings, impedance at normal & extreme taps short circuit duration, WTI ratio besides other information.
  - (b) Terminal marking plate showing the internal connections & voltage vector relationship of various windings in accordance with IS: 2026: 2006 (Latest Edition).
  - (c) Diagram plate showing the location and function of all valves and air release cocks or plugs.
- (xix). Oil conservator (for main tank) complete.
- (xx). One no. spare pocket on tank cover for thermometer.
- (xxi). Off-circuit tap changer
- (xxii). De-hydrating breather
- (xxiii). Anti earthquake clamping devices.

Any other item, which is not included above but is essential for the satisfactory operation of the equipment.

### **3.9 Insulating Oil**

The transformers and all associated oil-filled equipment shall be supplied along with the first filling of oil and 10 percent excess quantity of oil in non-returnable drums. The oil shall be free from moisture and have uniform quality throughout and shall conform to **IS 335**.

### **3.10 Oil Spill Collection**

The Scope shall comprise design of the oil spill collection system to cater oil spillage following fire or due to other reason, from the transformer.

For this purpose, **Contractor** shall design oil collection system below and all around pits of transformer.

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments & revisions as on date of opening of bid.

#### **4.0 STEEL STRUCTURES**

##### **4.1 General**

###### **4.1.1 Scope of Work**

Steel structural work shall include:

- (i). The preparation and supply of all necessary design calculations, material indents, arrangement drawings, shop details drawings, shops material lists, site bolt lists and dispatch documents for steel structures.
- (ii). Supply, fabrication, galvanizing, transportation, delivery and storage of all steel structures including bolts, rivets etc. complete in all respects.
- (iii). Erection including any staging or false work required for erection, handling, transport and rectification of damaged structures, fixing, bolting, welding, alignment, levelling, etc. of all steel structures, materials etc.
- (iv). Inspection of Structures.

###### **4.1.2 Scope of Supplies and Erection**

Scope of supplies and erection shall cover complete steel structural works for gantries, lightning mast, all equipment mounting structures except breakers. along with all bolts nuts washers, foundation bolts etc. as may be required for installation and proper functioning of the out door switch yard complete in all respect, according to the stipulations as indicated in this specification.

###### **4.1.3 Instruction to Tenderer**

- (i). The Tenderer shall ascertain himself, by visit to site, the actual site conditions, local factors etc. No claim due to any special site condition or ignorance of site condition shall be considered after the acceptance of his quotation.
- (ii). The successful tenderer shall arrange for procurement of steel, consumables etc. and also shall arrange for equipment, tools, tackles, instruments, galvanising etc. necessary for erection, complete in all respects as per approved drawings and specification.
- (iii). Owner approval of all structural drawings will be given in respect of design parameters, general arrangement and rationality of structural arrangement only. Such approval from the owner will not absolve the successful tenderer's responsibility for correctness and adequacy of the structural design.
- (iv). The successful tenderer shall furnish the quality assurance plan for owner/consultant's approval.

#### **4.2 Technical Specification**

##### **4.2.1 Design Parameters**

- (i). Structures shall be designed with adequate strength to meet the requirements of the equipment specified loading conditions stipulated and site condition.

- (ii). Structures shall be of generally of lattice type construction, fabricated out of mild steel rolled section and plates.
- (iii). All site connections shall be with bolts only.

#### **4.2.2 Codes and standards**

- (i). Super imposed loads (except wind load) to be considered for design shall conform to IS: 802 - 1977 (Part - I).
- (ii). Wind loading shall conform IS: 875 (Part - 3) -1987 with following consideration.
  - (a) Terrain Category: 1
  - (b) Class of Structure: A
  - (c) Probability Factor  $K1 = 1.0$
  - (d) Topography factor  $K3 = 1.0$
- (iii). Design of steel structures shall conform to IS: 802 - 1977 (Part - 1) and IS: 5613 (Part-3)-1985.
- (iv). Galvanizing of steel structures shall conform to IS: 4759 - 1990.
- (v). Bolts and fasteners shall conform to IS: 1367 (Part - 13) - 1978.
- (vi). Fabrication, galvanizing, inspection and packing shall be in accordance with IS : 802 (Part - 2) - 1978.
- (vii). Testing shall be in accordance with IS: 802 (Part - 3) - 1978.

**Note:** All works shall generally be executed in accordance with Indian standards and other relevant standards mentioned therein.

#### **4.2.3 Stability of Structures**

The stability of the structures as a whole or any part of it shall be investigated and weight or anchorage provided so that the least restoring moment including anchorage shall not be less than the sum of 1.2 times the maximum overturning moment due to dead load, and 1.4 times the maximum turning moment due to imposed loads.

In cases where dead load provides the restoring moments only 0.9 times the dead load shall be considered. The restoring moments due to imposed loads shall be ignored.

#### **4.2.4 Materials of Construction**

Structural steel shall conform to IS: 2062 - (Grade -A) -2026.

#### **4.2.5 Inspection**

All steel structures shall be subject to inspection by Owner.

#### **4.2.6 Erection, Testing & Commissioning**

These shall conform to IS: 802 (Part - 3) -1978.

### **5.0 BUS BAR, JUMPERS AND CONDUCTOR HARDWARES AND ACCESSORIES**

#### **5.1 General**

The bus bar is used to receive the power generated by Hydro Project through generator transformer and also to evacuate the power through transmission network

## 5.2 Relevant Standards

Applicable standards are R 28 to R 34 of reference at 1.2 above.

## 5.3 Type of bus bars

The outdoor bus bars are either of the rigid type or the strain type. In the rigid type, pipes are used for bus-bars while for strain type AAC or ACSR conductors are used and also for making connections among the various equipments, wherever required. The bus-bars and the connections are supported on pedestal insulators.

## 5.4 Bus Bar Material

The materials in common use for bus bars and connections of the strain type are ACSR and all aluminium conductors.

Technical Particulars of ACSR PANTHER/DOG Conductor Conforming to IS: 398(Part-III)- 1996 are given in Table 17.

**Table 17: Technical Particulars of ACSR PANTHER/DOG Conductor**

S. No.	Description	Panther	Dog
(i).	Wire Diameter		
(a).	Aluminium (mm)	30/3.00	6/4.72
(b).	Steel(mm)	7/3.00	7/1.57
(ii).	Sectional area of Al (sq.mm)	212.1	103.6
(iii).	Total sectional area (sq.mm)	261.5	118.45
(iv).	Over all diameter	21.00	14.15
(v).	Approx. wt. (kg/km)	974	394
(vi).	Calculated max DC resistance at 20 Deg Ohm/km	0.139	0.2745
(vii).	Min UTS (kN)	80	32.99
viii).	Final Modulus of elasticity(Kg/Sq.m)		0.735x10 <sup>6</sup>
(ix).	Coefficient of linear expansion per deg. C	17.8 x 10 <sup>-6</sup>	110.53 x 10 <sup>-6</sup>

In the case of rigid bus arrangement, aluminum pipes of Grade 63401 WP confirming to IS: 5082-1998 are commonly used. The sizes of pipes commonly used for various voltages are given below:

36 KV – 40 MM

Since aluminum oxidise rapidly great care is necessary in making connections. In the case of long spans expansion joints should be provided to avoid strain on the supporting insulators due to thermal expansion or contraction of pipe.

The bus bar sizes should meet the electrical and mechanical requirements of the specific application for which they are chosen.

## 5.5 Technical Particulars

Technical Particulars of bus bar are given in Table 18 (Example for 33 kV and 11 kV).

**Table 18: Technical Particulars of bus bars for 33 kV and 11 kV**

	Technical Particular		Values	Values
(a)	Nominal system voltage	:	33 kV	11 kV
(b)	Nominal current rating	:	1250 A	800 A
(c)	Bus conductor	:	ACSR Panther	ACSR Dog
(d)	Short time current rating for 3 sec.	:	25 kA	25 kA
(e)	Deflection of bus bar supported on post insulators shall not exceed.	:	Half the diameter of bus bar or L/14.4 cms (where L is the span in meters)	

## 5.6 Earth Wire

Technical particulars of earth wire should be in Table 19.

**Table 19: Technical particulars of earth wire**

S. No.	Description	Steel wire
(i).	Equivalent copper area (mm <sup>2</sup> )	
(ii).	Stranding and wire dia. (mm)	
(iii).	Dia. Over steel (mm)	
(iv).	Overall dia (mm) (std)	
(v).	Steel Area (mm <sup>2</sup> )	
(vi).	Mass kg/ km	
(vii).	Ultimate tensile strength (Newton)	
viii).	Breaking load (kg)	
(ix).	Coefficient of linear expansion (/ °C x 10 <sup>-6</sup> )	
(x).	Initial Modulus of elasticity (N/mm <sup>2</sup> )	
(xi).	Final Modulus of elasticity (N/mm <sup>2</sup> )	
(xii).	Calculated DC Resistance at 20 °C (ohms/km) (std)	
xiii).	Current rating (Amp)	

## 5.7 Strain Insulators and Hardware

The insulators for suspension and tension strings shall conform to IS: 731-1971. Insulator hardware shall conform to IS: 2486-1971. Other internationally accepted standards such IEC, BS, USA, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above.

## 5.8 Hardwares and Accessories for 33kV

S. No.	Insulators	Suspension	Tension
(i).	Type	Ball & Socket	Ball & Socket
(ii).	Ball Size	16 mm	20 mm
(iii).	Diameter	255 mm	255 mm
(iv).	E.M. strength	70 KN (	70KN
(v).	Length of string	To be specified by the bidder	To be specified by the bidder
(vi).	No. of discs		
<b>CLAMPS</b>			
		<u>Suspension</u>	<u>Tension</u>
(i).	Type	..... kV Envelope type	..... kV Compression type
(ii).	Material body	Aluminum Alloy	Extruded aluminum alloy
(iii).	Slipping strength	..... % of UTS of Conductor	..... % of UTS of Conductor
(iv).	Minimum failing Load	70 kN	70 kN (
<b>PG CLAMPS</b>			
(i).	Clamp body		Extruded Al. Alloys
(ii).	Flat or spring washer		Electro-galvanized
(iii).	All ferrous parts		Hot dip galvanized

## 6.0 INSTALLATION OF SWITCHYARD EQUIPMENT

### 6.1 General

- (i). All electrical installation shall conform to the Indian Electricity Act-2003, IE Rules and Regulation-1956 in force, in the state, by electrical inspectorate.
- (ii). All works under this contract including the installation of the equipments shall be got inspected and approved by the relevant authorities like Electrical Inspectorate etc.
- (iii). The circuit breaker, current transformers, lightning arresters, power transformers etc., shall be examined on receipt for damages. The contractor shall assemble, install and connect the equipment wherever necessary as per manufacturer's recommendations. The assembly of the unit including their operating mechanism, site adjustments shall also be carried out as per guiding instructions from the manufacturer. The equipment shall be placed and levelled carefully on their respective structures. All the preparatory works such as civil foundations, any concrete channels etc., shall be completed prior to this.
- (iv). The operating mechanism and control circuit of the equipment shall be tested for proper opening, closing and position indication. The opening and closing tests shall be made from control points as in service operation.
- (v). Earthing of supporting structures and metal parts of operating mechanism operating cabinets, operating handles at ground potential shall be ensured. Where moving parts are involved, flexible copper conductors shall be used.
- (vi). Before charging the equipment, contractor shall submit the completion report for each equipment indicating rectifications / modifications carried out during erection, site



- test certificates with observations, rectifications carried out. Contractor shall also indicate the correctness of operational and safety interlocks. Site test certificates shall also indicate the corresponding values obtained in the factory test.
- (vii). The conductor/jumpers shall be correctly and effectively connected to the terminals of equipment. The faces shall be cleaned with fine cloth and lightly coated with petroleum jelly before use. However, if contacts are silver plated, they shall not be cleaned with emery paper. The connection shall be flexible to withstand stresses during switching operation.
  - (viii). The control cabling shall be effectively crimped to the cable lugs which shall be bolted tight after ensuring that the contact faces are clean. Small wiring that is necessary between units in accordance with the diagram of connection shall be made complete.

## **6.2 Installation of Transformers**

- (i). The transformer and its accessories and mountings like radiators, conservator, Silica-gel Breathers, marshalling box, rollers etc shall be assembled at site after cleaning by the contractor in proper sequence as per manufacturer's Drawings.
- (ii). Contractor shall place the transformer on the channel at the location indicated in the layout drawing of outdoor yard Suitable stopper shall be provided both in front as well as rear of transformer to keep it stationary in its position. For the front wheels such stoppers shall be screwed on the channels.
- (iii). Oil shall be filled up to the mark shown
- (iv). Drying of transformer shall be carried out to get required dielectric strength as per relevant Indian Standards.
- (v). Wherever the power/control cables project above ground, for termination to cable box/marshalling box, the same shall be run in GI pipes of suitable cross section up to the height of 2.0 m from ground and the same shall be supported properly and pipe ends shall be sealed with epoxy compound.
- (vi). The contractor shall ensure the following sequence of erection of transformers:
  - (a) Unpacking of closed/packed cases and compare with the packing list,
  - (b) Physical check and inspection, pay particular attention to:
    - i. Tank sides or cooling tubes dented
    - ii. Protruding fitting damaged.
    - iii. Oil sight glass broken.
    - iv. Bushings cracked or broken.
    - v. Bolts loose due to vibration in transit
    - vi. Oil leakage
  - (c) Transportation to erection site.
  - (d) Erection on foundation /channels
  - (e) Assembly of transformer.
  - (f) Checking of oil level filtration / drying of oil.
  - (g) Alignment
  - (h) Anchoring and tack welding
  - (i) Mechanical check
  - (j) Wiring and sealing of assembled parts.
  - (k) Laying, meggaring, termination, dressing and clamping of cables
  - (l) Tagging and marking of cables
  - (m) Testing of cables.
  - (n) Earthing station, earthing of transformers, earthing strip, earth resistance to comply with IEC (latest revision)

- (o) Testing of assembled part
- (p) Testing and calibration of meters, relays, CTs, PTs, etc.
- (q) Connection of bus bars/ cables to primary and secondary of transformers.
- (r) Series of tests on transformers as per supplier's/ engineer's instructions, IS 1886 and manufacturer's recommendations.
- (s) Submission of completion report in the format
- (t) Charging of transformer.
- (u) Loading of transformer
- (v) Painting work
- (vii). Handing over to engineer/owner

**Note:** All high voltage tests shall comply with IS 2071 Part I-2004 and IS 2071 Part I-II-2006 -and all works in connection with the transformer shall comply with IS 1886-1961 and IEC (latest revision).

### **6.3 Installation of Circuit Breaker**

#### **6.3.1 General**

- (i). The circuit breakers shall be assembled and erected on the support structures as per the manufacturer's instructions and drawings and shall be aligned accurately and levelled on the support structures.
- (ii). Perfect operation of the circuit breaker shall be ensured after erection by manual operation. Each bearing of the operating mechanism shall be properly lubricated.
- (iii). The contractor shall follow the following sequence of erection of Circuit Breaker.
  - (a) Transportation to the place of installation from contractor's stores.
  - (b) Unpacking the cases and physical inspection of the components for breakages, missing parts or damage as compared with the packing list.
  - (c) The foundation must be plane and horizontal so that the Circuit breaker rest firmly on foundation.
  - (d) Assembly and erection of the circuit breaker shall be done strictly as per the instruction and drawings from the manufacturer. Corresponding part of each pole marked in the packing list shall be strictly adhered to. Breaker installation shall be checked for proper leveling and alignment.
  - (e) Adjust the operating rods between poles and the operating mechanism as directed by manufacturer, before closing the breaker at full speed. Check the "indicating distance" by operating the breaker slowly to the closed position.

#### **6.3.2 Wiring of the circuit breaker operating cubicle**

- (i). Laying, megging, termination, dressing and clamping of control cables, bus-bars, jumpers Etc.
- (ii). Testing and marking of cables.
- (iii). Cleaning of all insulating surfaces with dry cloth or as indicated by the manufacturer.
- (iv). Functional tests on the circuit breaker.
- (v). Painting of all accessories, structures etc.
- (vi). Earthing of all the metal parts and structures not intended to be live.
- (vii). Submission of site test certificates, completion report etc., in the proper format.
- (viii). Handing over to engineer/owner.

#### **6.4 Installation of Isolator/Disconnecting Switch**

- (i). The poles of the disconnecting switches shall be aligned accurately and levelled on the supporting steel structures. Sequence of installation of disconnecting switch parts shall be carried out as recommended by manufacturer.
- (ii). Perfect operation of disconnecting switch, earthing switches shall be ensured after erection by manual operation. Working clearance between adjacent structures and switch blades in open position shall be checked.
- (iii). The switches shall be adjusted so as to permit operation with ease by one man. Each bearing of the operating mechanism shall be properly lubricated.
- (iv). Laying, termination of power and control cables, checking of internal wiring connections.
- (v). The contractor shall also check for the key interlocking of the earthing switch with the main disconnect switch. Earthing between units, earthing terminals to structure, operating handle to structure and ground mat should be effective and neatly taken through structures and foundation. Ground mat shall be positioned right below the operating handle of the disconnect switch, visible at all times.

#### **6.5 Installation of Current Transformer/ Pot entail Transformer**

- (i). Current and Potential transformers shall be mounted on the steel supporting structure with secondary terminal boxes in pre-determined position so that cable can be conveniently taken without much bends and twisting.
- (ii). Interconnection wiring' should be kept as short as possible, both for economy and to produce low burdens. The cable shall be taken neatly through suitable galvanised iron conduits to trench sections wherever required.
- (iii). Apart from general earthing, one terminal of secondaries of current transformers shall be earthed solidly through adequate section of solid copper conductor.

#### **6.6 Installation of Lightning Arresters**

The lead connecting lightning arrester with line should be direct without any splice or other joint and the connection should be effective to carry the lightning discharge currents. The lightning arrester shall be positioned in such a way that short and straight leads can be run from the earthing terminal of the arrester to the earth electrode specifically provided for this purpose. The arrester exhaust ports should be directed away from the equipment and other arrester.

#### **6.7 Installation of Connecting Materials in Switchyard**

- (i). The arrangement of connections shall be such that the connected apparatus are not subjected to any mechanical stress due to expansions, contractions etc. of the connections.
- (ii). The connections shall ensure good electrical contact. The connector and joints shall be rigid to withstand all mechanical and electrical stresses. Suitable bi-metallic clamps shall be used for all the connections between the conductors of different materials.
- (iii). All live parts shall have sufficient practical clearances from earthed parts and ground. The clearances of strung busbar shall be decided considering the effect of

- sag. In applying clearance an allowance shall be made to cater for variation in making foundation and in the dimensions of structures and buildings.
- (iv). The contractor shall be responsible for supplying and installing the various conductors required for connection of the various equipment. The tenderer's scope shall include all bolts, nuts and washers required for installation. All connections etc., shall be so made that stress between connecting terminals will be reduced to the minimum.
  - (v). The physical layout of the system shall be such that the system extension or conversion can be carried out with minimum changes and easy methods. Further, it shall be ensured that all civil works for the foundations are completed by the contractor before taking up erection of structure.

## **6.8 Installation of Grounding/Earthing**

- (i). Entire system shall be earthed in accordance with the provisions of the relevant IEC recommendations / IS code of practice IS 3043-2006 and Indian Electricity Rules, so that the values of the step and touch potentials in case of faults, are kept within safe permissible limits.
- (ii). The principal requirements of the grounding are :
  - (a) Low resistance and adequate current carrying capacity.
  - (b) Uniform and near uniform ground potential on all structural Metal work on all metal enclosures and/or supports of equipment and apparatus.
  - (c) The resistance of earthing network shall be less than 1 ohm for the network of outdoor yard under all conditions. The earthing network shall be as per actual site conditions.
- (iii). The contractor's scope of installation will also include all the civil work associated with complete earthing network.
- (iv). All earth connection shall ensure a permanent low resistance contact. Earth connections required to be removed for the purpose of testing of equipment/earthing network shall have bolted connection and joints fastened. All earthing connections shall be visible for inspection.
- (v). Switchyard fencing and all equipment located at switchyard, shall have 2 separate distinct earth connections.
- (vi). Lightning arresters and transformer neutrals shall be connected to two independent earth electrodes as per IS 3043-1987.
- (vii). Air termination rods of lightning protection systems shall be connected to earthing network as per IS 3043-1987.
- (viii). The grounding connection to the lightning arresters, air termination points of lightning protection system shall be as short as possible. Sharp turns in these conductors shall be avoided.
- (ix). It has to be ensured that main earth bus in the installation as well as earth buses in individual sections/areas shall form complete ring and they shall be interconnected.
- (x). Duplicate earthing (two separate and distinct connections with earth) shall be employed for all equipments.
- (xi). Wherever burying of earth conductors are specified, they shall be buried as per approved drawings.
- (xii). Wherever earth conductor crosses the road, it shall be taken through GI pipes.
- (xiii). At all terminations of earth conductors on equipments, sufficient length shall be left for easy movement of the equipment from its position for alignment purposes.

- (xiv). Wherever not detailed, the route of the conductor and location of the earth pit shall be arranged, so as to avoid obstructions, crossing etc., according to convenience at site and shall be got approved by the owner's representative in-charge of the work.

### **6.8.1 Joints/Terminations of Earth Strips**

- (i). All joints of bare galvanised earth strips shall be welded so as to form rigid earth ring. All such welded joints shall be given necessary coating of cold galvanised paint as per relevant standards and a coat of suitable bitumen compound to prevent corrosion. Welded joints shall form part of laying of earth conductors and they shall not be considered as terminations for payment purposes. No extra costs shall be applicable for joints of all the earth conductors.
- (ii). In case the joints are made by using suitable connectors the entire joint shall be fully sealed by suitable compound so that no metallic part is exposed.
- (iii). The contractor shall make his own arrangements for the necessary crimping tools, soldering equipments, drilling machines and other tools and tackles which are necessary for completing the installation.

### **6.9 Civil Works of Switchyard**

A typical civil work specification for 33 kV switchyard are given below:

- (i). Contractor's scope includes design, preparation of drawings and construction at site the civil works required for the equipment under his scope . The work is briefly given below:
- (a) Cable trenches
  - (b) panel supporting frames in floor
  - (c) Chequered plate covers on cable trenches
  - (d) 2 meter high chain link fencing including posts, gate, etc. in switchyard.
  - (e) Equipment foundation in switchyard.
- (ii). Bidder shall carry out civil work in accordance with PWD specification and with the approval of the purchasers engineer.
- (iii). Minimum grades of concrete for equipment foundations shall be as under:
- Mix. 1: 1 ½ : 3 ( M-200 grade )
- (iv). Cable trenches :Mix 1 : 2 : 4 (M -150 grade )
- (v). Lean concrete :Mix. 1 : 4 : 8
- (vi). Walls and slabs of trenches shall be of minimum 150 mm thick.
- (vii). Cable trench walls shall be designed for a load of 750 kg/ m. sq. in addition to earth lateral pressures.
- (viii). Floor of the trenches shall be given a slope of 1: 250 in order to provide drain outside the pump house for accumulated water. Slope in outdoor switchyard shall be directed outside the pump house area.
- (ix). All openings in wall, foundation for cable entry in / out of the building shall be blocked and sealed to prevent water entering in to the building.
- (x). Chequered plate shall be minimum 8 mm thickness and shall be designed for live load of 750 kg/m.sq.
- (xi). Minimum depth of equipment foundation shall be 1.8 meters below ground level.

- (xii). Spreading of gravel 100 mm thick and watering for earth pit shall be done after all other civil work is complete. All equipment's shall be cleaned for dust after completion of work. Watering pipe shall be laid as per drawing.

#### **6.10 Erection and Commissioning, Tools and Tackles**

- (i). The contractor shall provide all tools/tackles, jigs and fixtures, alignment tools, testing kits, testing meters/instruments, breaker, handling devices, all consumable items and construction equipment as required in installing the work, complete in all respects and shall include but not be limited to bolts, nuts, rivets, welding rods, shims, wedges, packing sheets, packing compounds, oil, flushing oil, protective greases and oils, all materials required for proper installation and protection of individual equipment in storages, and during erection, testing and commissioning.
- (ii). This shall also cover proper alignment, tack welding, tagging, laying, marking of and connection of cables, fabrication, supply and installation of all support structures for installation of various electrical equipments and cables.
- (iii). Supply and installation of first aid boxes, shock treatment charts, rubber mats, keyboard.
- (iv). The rubber mats shall be provided in front of all control panels/switchgears to comply with Indian Electricity Act.
- (v). Erection, testing and commissioning of various equipments shall be done strictly as per manufacturer's instructions.
- (vi). All plant and -equipment the painting of which has been damaged during transportation/erection or by corrosion shall be given two coats of paint after removal of scales, rust, oil etc.
- (vii). All iron frame work erected shall be provided with one under coat of primer and one top coat of finish paint.
- (viii). Cable shall be always laid in conduit upto 2 meter of height in case of vertical run to avoid mechanical damage.
- (ix). Cable shall be laid in separate racks according to voltage levels and between two cables horizontal clearance equal to diameter of cables shall be provided in the hooks.
- (x). Maximum cross section areas of cable passing through conduit shall not exceed 60% of cross section of conduit.
- (xi). Approved type of danger boards, boards inscribing 'EARTHED', 'DO NOT CLOSE', 'MEN AT WORK' etc, shall be provided in sufficient numbers.
- (xii). Special care shall be taken to make the enclosed equipment protected against entry of rats, lizard, and creeping reptiles which may create electrical short circuits.

#### **6.11 Stages of Completion of Works**

The stages of completion of various works shall be as follows:

##### **6.11.1 Completion of Erection**

Equipment shall be considered to be completely erected when the following activities have completed.

- (i). Moving of all equipment to the respective foundations.
- (ii). Aligning the equipment.
- (iii). Fixing of anchor bolts or tack welding as required.

- (iv). Drying of equipment as required and testing of oil for dielectric strength.
- (v). Assembling of all accessories such as relays, CTs, PTs, meters, instruments etc. as described in job specification.
- (vi). Filtration and filling of oil as required.
- (vii). Cable laying termination with continuity checking.
- (viii). Applying of finish coat of paint.
- (ix). Completion of earthing system.
- (x). Removing of unwanted materials and covering of all openings including cable openings, conduits etc.

In other words, erection shall be considered to be complete where the equipment is ready for testing with all other associated equipments required for commissioning. In this matter the opinion of Owner/Consultant shall be final.

### **6.11.2 Completion of testing**

Testing of equipment shall be considered as complete after the following operational tests.

- (i). Testing/commissioning of all panels and equipments as specified.
- (ii). Checking of all circuits/ schemes for correct connections and continuity.
- (iii). Reworking as required during testing and retesting.

### **6.11.3 Charging of the equipments in sequence and commissioning.**

## **6.12 Guidelines for Clearance in Electrical Premises**

### **6.12.1 All the substation building sizes shall be decided as per the following guidelines:**

- (i). All equipment/ panels shall have minimum 1250 mm back clearance all around them.
- (ii). The front to front clearance of switch boards / panels shall be minimum 2500 mm.
- (iii). Clearance between two panels installed in a row shall be minimum 1000 mm.
- (iv). Clearance between wall and end of the panels shall be minimum 1000 mm.

### **6.12.2 Cable Channels**

- (i). The cable channels shall have removable covers for the full width.
- (ii). Minimum working passage of 500 mm shall be provided between cable racks or between cable rack and wall.
- (iii). Shall have suitable drainage facility to avoid accumulation of seepage water.

### **6.12.3 Safety partitions and entries**

- (i). Doors shall be provided for electrical buildings.
- (ii). All the cable openings on the equipment floor shall be sealed.

**6.12.4 The following provision shall be made for transformer oil soak pit and oil collection pit.**

- (i). For a single transformer installation oil soak pit capacity shall be 110% of transformer oil capacity.
- (ii). For multi transformer installation oil soak pit capacity shall be 30% of individual transformer oil capacity and in addition to it an oil collection pit of 150% capacity of largest transformer shall be provided.
- (iii). Oil soak pit dimension, shall be all around 800mm more than the overall (length & width) dimension of transformer including radiator.

**7.0 INSPECTION AND TESTING**

**7.1 Inspection of Switchyard Equipment**

**7.1.1 General**

Inspection & testing of equipment covered under the Technical Specification shall be carried out by the Owner at the manufacturers' works/ premises prior to dispatch to ensure that their quality & workmanship are in conformity with the contract specifications and approved drawings.

**7.1.2 Inspection & testing stages and finalization of Quality Assurance plan (QAP)**

Within 4 weeks of the award of contract the contractor shall furnish the Quality Assurance Plan as per standard Performa.

Inspection & testing of plant & equipment shall be undertaken by the Owner after finalisation & approval of QAP.

**7.1.3 Responsibility for inspection**

Any inspection by the Owner does not relieve the responsibility of quality assurance and quality control functions, as expected of the contractor to be performed by him for supply of plant & equipment as part of the contractual obligations.

**7.1.4 Extent of Inspection**

Routine test as per latest relevant IS for 100% equipment.

Type test shall be carried out on each type of equipment for which the tenderer fails to produce Type Test Certificates carried on similar type of equipment within 3 years period.

**7.1.5 Tests, Test certificates and Documents**

For each of the items being manufactured, following test certificates and Documents (as applicable for each of the equipment) in requisite copies shall be prepared and submitted to the Inspection Engineer for scrutiny & records.

Routine / type / calibration / acceptance / special test certificates for electrical items.



Certificates from competent authority for the items coming under statutory regulations.

Should the result of tests not come within the margin specified, the tests shall if required be repeated at Contractor's cost without any liability to the Owner.

### **7.1.6 Methods of giving inspection calls**

Inspection calls shall be given by the contractor with ten days notice period. All calls shall accompany two sets of relevant test certificates and inspection report of the Contractor /sub- contractor after satisfactory completion of internal inspection and tests by them as per approved QAP .Inspection calls without enclosing relevant test certificates & internal inspection report shall not be entertained.

Test of all equipment shall be conducted as per latest IS.

The site tests and acceptance tests to be performed by contractor are detailed below.

The contractor shall be responsible for satisfactory working of complete integrated system and guaranteed performance.

## **7.2 Testing of Switchyard Equipment**

### **7.2.1 Site Tests and Checks**

All the equipment shall be tested at site to know their condition and to prove suitability for required performance.

Following tests shall be conducted after installation. All tools, accessories and required instruments shall have to be arranged by the Tenderer.

Any other tests which is considered necessary by the manufacturer of the equipment has to be conducted at site.

The tests to be carried out on the equipment at pre-commissioning stage shall include but not limited to the following

### **7.2.2 Circuit Breaker**

- (i). IR test on each pole by Meggar (Between poles and lower poles to ground).
- (ii). IR tests on control circuits.
- (iii). Functional check of breaker operation on minimum and maximum specified control voltages.
- (iv). Checking of interlocks with isolators & earthing switches.
- (v). Measurement of contact resistance.
- (vi). Checking of operation and tripping of protection release.
- (vii). Checking tightness of termination connectors and earthing connections.
- (viii). Checking of insulators for cracks etc.
- (ix). Check for closing and opening time and simultaneous closing of all poles through oscillograph.

- (x). Tripping of circuit breaker at reduced or over voltage i.e. at 60% & 110%.
- (xi). Checking of Gas pressure, Sealing and packing.
- (xii). Checking of leakage.

### **7.2.3 Isolator/ Disconnecting switches**

- (i). IR test by HV Meggar on main poles.
- (ii). IR test on control circuits.
- (iii). Measurement of contact resistance for all three phases.
- (iv). Functional checking for manual operation.
- (v). Checking of interlocking with earth switch
- (vi). Checking of earth switch operation.
- (vii). Checking tightness of earthing connections.
- (viii). Checking of insulators for cracks.

### **7.2.4 Lightning Arrester**

- (i). Continuity check (for metal oxide type only)
- (ii). Check for connection to ground.
- (iii). Check insulators for cracks.
- (iv). HT and IR test of each element.
- (v). Check reading of leakage current

### **7.2.5 Current Transformer**

- (i). IR test on each winding, winding to earth and between windings.
- (ii). Checking of winding ratios by primary injections set.
- (iii). Polarity check on each winding.
- (iv). Continuity check for all windings
- (v). Check for connections to correct taps.
- (vi). Checking of oil level
- (vii). Checking of continuity and IR values for cables from CT to Marsh Box.
- (viii). Checking tightness of earthing connections.
- (ix). Checking of insulator for cracks.
- (x). Check output after loading of the main circuit.

### **7.2.6 Potential Transformer**

- (i). IR test on each winding, winding to earth and between windings.
- (ii). Polarity check on each winding.
- (iii). Continuity check for all windings
- (iv). Turns ratio test
- (v). Check for connections to correct taps.
- (vi). Checking of oil level
- (vii). Checking tightness of earthing connections.
- (viii). Checking of insulator for cracks.

### **7.2.7 Power Transformer**

- (i). IR test on each winding to ground and between windings.

- (ii). Turns ratio test on each tap.
- (iii). Polarity and vector group test.
- (iv). Measurement of winding group test.
- (v). IR, wiring and operational tests on all control devices in control cabinet oil level indicator, winding and oil temp. Indicators etc.
- (vi). Checking of earthing water transformer tank (flexible from top cover to tank) other parts, neutrals.
- (vii). Testing of buchholz relay for alarm and trip conditions.
- (viii). Setting of oil/ winding temperature indicators , level gauge and checking of alarm/ trip circuits.
- (ix). Check insulators for cracks.
- (x). Checking for oil leakage and arresting of leakages (if observed).
- (xi). Checking for open position of all the valves ( except drain and filter valves).
- (xii). Filtrations of oil by using line filter, vacuum pump, and heater set.
- (xiii). BDV test on oil samples from top and bottom.
- (xiv). Measurement of magnetising current and no load loss.
- (xv). Measurement of PI Value.
- (xvi). Checking of silica-gel breather.
- (xvii). Checking of other points given in manufacturer's commissioning manual.

#### **7.2.8 Insulators**

- (i). Checking tightness of connections.
- (ii). Check for minor damage/ cracks after cleaning.
- (iii). Verification of number of disks as per drawings.
- (iv). Check, heating at termination point during shut down.

#### **7.2.9 ACSR Conductor**

- (i). Check for continuity
- (ii). Check for tightness of connections for all the termination points.
- (iii). Check for phase sequence marking and for their correctness.
- (iv). Physical verification

#### **7.2.10 Earthing**

- (i). Check tightness of all each connections.
- (ii). Check earthing of all metallic equipment, busbar supporting structures, yard Fencing steel structures of yard, rails, gates, building column (if steel) all elect, equipment water pipe lines etc. as per the drawing/ specification.
- (iii). Measurement of earth resistance for each electrode.
- (iv). Measurement of total earth resistance.

#### **7.2.11 Lightning Protection**

- (i). Check continuity of all the earth strips/shield wire.
- (ii). Check tightness of all connections.
- (iii). Measure earth resistance of each electrode and combined system.

## 7.2.12 Miscellaneous

- (i). Checking of continuity of the system.
- (ii). Checking of phase sequence from overhead line to consumer end.
- (iii). Checking safe accessibility of all operating points.
- (iv). Check availability of control/aux. supply.

## 8.0 GUARANTEED TECHNICAL PARTICULARS TO BE SUBMITTED BY THE TENDERER

### 8.1 SF6 Circuit Breaker

1. Name of manufacturer
2. Manufacturer's type designation
3. Type SF6
4. Standards followed
5. Suitable for outdoor duty Yes
6. Rated voltage (kV)
7. No. of poles of circuit breaker
8. Continuous current rating (A)
  - i. Under normal conditions (amps) (at °C)
  - ii. Under site conditions (amps)
9. Short time current rating
  - i. 1 second, kA (rms)
  - ii. 3 seconds, kA, (rms)
10. Maximum temperature rise over ambient of different parts, °C.
11. Breaking capacity
  - a) Symmetrical kA rms.
  - b) Asymmetrical, kA
12. Making capacity, kA (peak)
13. Kilometric fault level, MVA
14. Maximum interrupting capacity under phase opposition condition MVA
15. Maximum line charging current breaking capacity without the over-voltage exceeding 2.5 to 3 times the rated phase to neutral voltage.
16. Maximum line charging current breaking capacity and corresponding over voltage receded in test.
17. Total break time (measured from instant of trip coil energization)
18. Arcing time, ms.
19. Make time) ms
20. Dry and wet 1-minute power frequency withstand test voltage for complete circuit breaker
  - a) between phase to phase, kV(rms)
  - b) between phase to ground, kV(rms)
21. 1.2/50 micro-second full wave impulse withstand voltage for complete circuit breaker.
  - a) between phase to phase kV(peak)
  - b) between phase to ground kV (Peak)
22. Dry 1 -minute power frequency withstand voltage for insulator kV(rms)
23. 1.2/50 micro-second full wave impulse withstand voltage for the insulator, kV(peak)

24. Creepage distance to ground, mm
  - a) between phases
  - b) live parts to earth
  - c) live parts to ground level
25. Number of break per phase
26. Total length of break per phase, mm
27. Rate of contact travel, mm/sec.
28. Type of main contacts
29. Type of auxiliary contacts.
30. Material of auxiliary contacts.
31. Main contacts silver plated or not, if yes, thickness of silver plating
32. Number of trip coils in each breaker. Number of auxiliary contacts provided:
33.
  - a) Those closed when breaker is closed.
  - b) Those open when breaker is closed.
  - c) Those adjustable w.r.t. the position of main contact.
  - d) Rating and braking capacity of each contact.
34. Type of operating mechanism
  - a) Opening
  - b) Closing
  - c) Emergency tripping
35. Control cum circuit volt. For close/trip coil (volt)
36. Power required for closing coil/trip coil (watt)
37. Duty cycle.
38. Anti pumping device.
39. Weight of three phase breaker complete with operating Kg mechanism bushing frame work etc.
40. Overall dimensions(mm x mm x mm)
41. Confirm that all details given in technical particulars are provided Yes/No
42. If answer is 'NO' in 41, indicate point wise deviation.
43. Manufacture's catalogue enclosed Yes/No

## 8.2 Vacuum Circuit Breakers

1. Name of Manufacturer
2. Manufacturer's Type Designation
3. Standards applicable
4. Characteristics
  - Mechanical Characteristics
  - No. of Poles
  - Opening time and break time.
  - Closing time.
  - Degree of Vacuum maintained in the Vacuum chamber.
  - Minimum Clearance in Air:
    - Between poles
    - Between live parts to earth.
  - Whether circuit breaker is trip free.
  - Whether type test reports enclosed.
  - Whether the special guarantee for vacuum bottles for five years is accepted.
  - Electrical Characteristics
  - Voltage Class

Rated Normal current  
 Rated Voltage  
 Rated Insulation level  
 One minute power frequency withstand voltage  
 Impulse withstand voltage  
 One minute power frequency withstand voltage on auxiliary wiring.  
 Rated frequency.  
 Rated cable charging current  
 Rated (Single) capacitor breaking current  
 Rated small inductive breaking current  
 Rated short circuit making current  
 Rated duration of short circuit  
 Rated transient recovery current.  
 Rated operating sequence.  
 Electrical service life  
 Rated current (times)  
 Rated interruptions current (times)  
 Gap between the contacts in vacuum.  
 Area of contacts.  
 The voltage to which the circuit breaker shall be capable of withstanding indefinitely across open contacts.  
 Weight of Complete Circuit Breaker :  
 Operating Mechanism of Circuit Breaker and Associated Equipment.  
 Type of closing mechanism  
 No. and type of auxiliary contacts.  
 (No. of spare normally open contacts and no. of spares normally closed contacts are to be indicated.).  
 Power requirement:  
     Closing Coil.  
     Opening Coil  
     Heaters at different locations (240V-50c/s AC)  
 IR values of the pole assemblies with 5 KV megger  
 R Phase live part to body  
 Phase incoming to outgoing terminals.  
 Y Phase live part to body.  
 Y Phase between incoming to outgoing terminals  
 B Phase live part to body  
 B Phase between incoming to outgoing terminals.

### **8.3 Isolator**

1. Manufacturer's name
2. Manufacturer's type designation
3. Standards applicable
4. Type   Single/double break  
          Horizontal/vertical
5. Rated voltage kV
6. Rated frequency
7. Current rating
  - a.) Continuous A (at design temp.)

- b) Current rating at site condition A
- c) Dynamic through fault kA
- d) 3 second rating kA
- e) Making current A
- 8. Design ambient temperature (° C)
- 9. Maximum temperature of current carrying parts when carrying rated current at specified ambient temperature, ° C
- 10. Maximum temperature of current carrying parts when carrying short circuit current for 3 seconds, °C
- 11. One minute power frequency dry & wet withstand voltage
- 12. 1.2 / 50 micro sec. Impulse withstand voltage.
- 13. Switch contact particulars
  - a) Type of main isolating contacts
  - b) Area & material of contacts.
  - c) Thickness of silver facing
  - d) Blade material
- 14. Number of auxiliary contacts on disconnecting switch
- 15. Rating of auxiliary contacts
  - a) Continuous A
  - b) Breaking current at --- V DC.
- 16. Type of interlock between earthing blade and isolator
- 17. Particulars of isolator operating mechanism
- 18. Duty Outdoor/Indoor
- 19. No. of operations, the disconnecting switch can withstand without deterioration of contacts.
- 20. Clearance
  - a) Between phases, mm
  - b) Between live parts & earth, mm
  - c) Between fixed contacts and blade in open position, mm
- 21.
  - a) Capacitive current that can safely be interrupted by the switch, A
  - b) Magnetizing current that can safely be interrupted by the switch, A
- 22. Type and make of insulator
- 23. No. of insulators per stack
- 24. One minute dry & wet withstand voltage per stack, kV (rms)
- 25. Impulse withstand voltage of insulator stack at 1.2/50 micro seconds positive full wave, kV(peak).
- 26. Creepage distance
  - a) Total mm
  - b) Protected mm
- 27. Total weight, Kg.
- 28. Dimensions of switch LxBxH (mm x mm x mm)
- 29. Shipping dimension of largest package
- 30. Provision of earthing switch One side/both side
- 31. G.A. drg. Of disconnect switch along-with support structure Submitted/not submitted
- 32. Supporting structures
  - a) Material
  - b) Total weight/Isolator, kg.
  - c) Thickness of galvanizing, micron
  - d) Total height of structure in mm

33. Power and control power supply voltage. Yes/No
34. Confirm that all particulars given in technical particulars are acceptable to tenderer
35. If answer is 'NO' in above then indicate point wise deviation

#### 8.4 Current Transformers

1. Name of manufacturer
2. Manufacturer's types designation
3. Type
4. Standards followed.
5. Rated Voltage(kV)
6. Rated primary current/voltage
7. Rated secondary current/voltage
8. Number of cores Rated output Class of accuracy Accuracy Limit factor  
Core I  
Core II  
Core III .
9. Short time current rating  
i) 1 second, kA (rms)  
ii) 3 seconds, kA (rms)
10. Dynamic current kA (peak)
11. Temperature rise over max. site ambient °C  
i) Oil at top of housing (°C)  
ii) Winding (°C)
12. Class of insulation
13. Current/voltage and phase errors at rated burden and frequency
14. Confirm that all particulars given in technical data sheet are acceptable. Yes/No
15. If answer is 'NO' in 14, indicate point wise deviation.

#### 8.5 Lightning Arrester

1. Manufacturer's name
2. Manufacturer's type designation
3. Applicable standard(s)
4. Arrestor class and type
5. Rated arrester voltage kV (rms)
6. Nominal system voltage, kV (rms)
7. Rated frequency, Hz
8. Nominal discharge current (8/20 micro sec. wave) kA (peak)
9. Max, 100% 1.2/50 micro sec. Spark over voltage, kV (peak)
10. Max. front of wave spark over voltage, kV(peak) & front steepness kV/sec.
11. Max. residual voltage at rated nominal discharge current kV(peak)
12. Impulse current withstand  
a) High current short duration (4/10 micro sec. Wave), kA (peak)  
b) Low current long duration, Amps.(peak)
13. Wet and dry power frequency withstand voltage for the housing, kV (rms)
14. Impulse withstand strength of arrester housing, with 1.2/50 micro-sec. Wave kV (peak)



15. Total creepage distance of the arrester housing, mm
16. Protected creepage distance of the arrester housing, mm
17. Total weight of material included for Supporting structures Thickness of galvanizing, micron Total height of structures in mm
18. Suitable for outdoor duty. Yes/No
19. Confirm that all particulars given in tech. Part sheet are Yes/No acceptable.
20. If answer is 'NO' in 19 indicate point-wise deviation

## 8.6 Potential Transformers

1. Manufacturer's name & type designation
2. Type
3. Rated voltage
4. Rated primary voltage (kV)
5. Rated secondary voltage (V)
  - Winding - I
  - Winding - II
6. Rated burden (VA)
  - Winding - I
  - Winding - II
7. Accuracy class
  - Winding - I
  - Winding - II
8. Maximum ratio error with rated burden and 5% normal primary voltage
9. Maximum phase angle error with rated burden and 5% normal primary voltage
10. Variation in ratio and phase angle error for variation in
  - a) Voltage by 1%
  - b) Frequency by 1 Hz
11. Temperature rise at 1.1 times rated voltage with rated burden
12. Rated voltage factor and time
13. 1.2 / 50 micro second impulse wave withstand test voltage (kV peak)
14. One minute power frequency withstand test (dry) voltage –kV rms.
15. One minute power frequency withstand test (wet.) voltage -kV rms.
16. One minute power frequency withstand voltage on secondaries (kV rms.)
17. Minimum creepage distance (mm)
  - a) Moderately polluted atmosphere
  - b) Heavily polluted atmosphere
    - i) Total
    - ii) Protected
18. Whether corona shield provided or not
19. Weight of oil (KG)
20. Total weight (KG)
21. Overall dimensions
22. Mounting details

## 8.7 Generator Transformers

1. Name of manufacturer
2. a. Service- whether indoor or outdoor Outdoor
- b. Type (Core or shell)

3. Reference standard
4. Type of cooling
5. Rating
  - a. Rated KVA
  - b. Rated current, amp (rms) HV/LV
  - c. Rated voltage, kV (HV/LV)
6.
  - a. Temperature rise above 50 °C. Ambient for oil filled type
    - i. In oil by thermometer, °C.
    - ii. In winding by resistance, ° C.
  - b. Hot spot temperature in winding limited to, °C.
7.
  - a. Windings
    - i. No. of windings per phase
    - ii. Insulation class
  - b. Connections
    - i. Vector group reference (in accordance with IS: 2026)
  - c. Terminal arrangement
    - i. HV
    - ii. L.V.
  - d. Winding insulation category
    - i. HV Uniform/Non-Uniform
    - ii. LV Uniform/Non-Uniform
  - e. Insulation level as per IS: 2026(Part-III) or IEC-76-3
8. Type of tap changer
9. Taps
  - a. Capacity
  - b. Steps and range
  - c. Tapping provided on HV side
10. Losses
  - a. No -load loss at rated voltage and frequency
  - b. Load loss at rated current and at 75 °C.
11.
  - a. Impedance at rated current frequency and at 75 °C %
  - b. Reactance at rated current and frequency. %
  - c. Resistance at rated current and at 75 °C,%
  - d. Zero sequence impedance, %
  - e. Zero sequence capacitance of
    - i. L.V. winding, microfarad/phase
    - ii. HV winding, micro farad/phase
12. Efficiency at 75 °C and .80 p.f lag %-
  - a. at 100% load
  - b. at 75% load
  - c. at 50% load
13.
  - a. Load and power factor at which maximum efficiency occurs, % full load
  - b. Maximum efficiency, %
14. Regulation at full load and at 75 ° C
  - a. At unity power factor, %
  - b. At 0.80 power factor lagging, %
15. No load current referred to H.V. and 50 C/S....% rated current
  - a. At 90% rated voltage
  - b. At 100 % rated voltage
  - c. At 110% rated voltage

Yes/No

- d. At 125% rated voltage
16. i. Approximate maximum flux density  $\text{Web/m}^2$
- at 90% rated voltage, 50Hz
  - at 100% rated voltage, 50Hz
  - at 110% rated voltage, 50Hz
  - at 125% rated voltage, 50Hz
  - at 140% rated voltage, 50Hz
- ii. Following particulars shall be provided for the worst condition of simultaneous occurrence of 110% rated voltage and 95% rated frequency.
- Maximum flux density
  - Temperature rise
  - Period of allowable operation under the above worst condition
17. Maximum current density,  $\text{Amps/Cm}^2$
- H.V. winding
  - L.V. winding
18. Clearance in mm.
- |                             |           |
|-----------------------------|-----------|
| Minimum clearances in mm    | H.V. L.V. |
| a. Between phase            |           |
| i. In Air                   |           |
| ii. In Oil                  |           |
| b. Between phase and ground |           |
| i. In Air                   |           |
| ii. In Oil                  |           |
19. Withstand time without injury for
- There phase dead short circuit at terminal with rated voltage maintained on the other side, sec.
  - Single phase short circuit at terminal with rated voltage maintained on the other side, sec.
20. Insulation strength
- One minute power frequency test kV rms.
    - HV
    - LV
    - LV Neutral
  - Impulse withstand voltage, kV
    - H.V.
    - L.V.
    - L.V. Neutral
21. Tap-changer
- |   |        |
|---|--------|
| a. Tap -changer operable at standing height from ground | Yes/No |
| b. Provided with  |        |
| i. Tap position indicators                              | Yes/No |
| ii. Operation counter                                   | Yes/No |
| iii. Padlocking provisions                              | Yes/No |
| c. All contacts silver plated                           |        |
22. a. Details of Tank
- Material
  - Maximum internal pressure the tank is capable of withstanding  $\text{kg./ Cm}^2$
23. Explosion vent
- Minimum pressure the diaphragm is set to rupture,  $\text{kg/cm}^2$
24. Details of core material
25. Insulation material
26. Details of bushings
- |         |                      |
|---------|----------------------|
|         | H.V. L.V. LV Neutral |
| a. Make |                      |
| b. Type |                      |

- c. Voltage class, kV
- d. Creepage distance, mm
- e. Free space required at top for bushing removal mm
- f. Minimum clearance in air
  - i. Phase to phase, mm ii. Phase to earth, mm iii. Phase to neutral, mm
- g. Impulse withstand voltage, kV (peak)
- h. Power frequency withstand voltage kV (rms)
- 27. Insulation Oil
  - a. Approx volume of oil litre
  - b. Whether first filling of oil with 10% excess included?
  - c. Oil conforms to IS: 335
- 28. Marshalling Box
  - a. Weatherproof, suitable for outdoor for oil filled type?
  - b. Degree of protection
- 29. Terminal blocks
  - a. Make
  - b. Whether stud type terminals are offered? Yes/No
  - c. 10% spare terminals furnished? Yes/No
- 30. Wiring
  - a. Cable type
  - b. Voltage grade volt
  - c. Conductor size
    - i. Current circuits mm<sup>2</sup>
    - ii. Other circuits mm<sup>2</sup>
- 31. Contact rating, Amps x Volt DC Making Inductive Breaking
  - a. Buchholz relay
  - b. Oil temperature indicator
  - c. Winding temperature indicator
  - d. Magnetic oil level gauge
- 32. a. Material of gaskets
  - b. No. of gaskets for one complete set (break up of gaskets shall be given)
- 33. a. Type of valve
  - b. No. of valve comprising one complete set (break up of valve shall be given)
- Tests
- 34. a. Routine test as per IS: 2026-1997
  - b. Tank pressure test
    - i. Pressure, kg/cm<sup>2</sup>
    - ii. Duration, hour
  - c. Tank vacuum test
    - i. Vacuum, mm of Hg
    - ii. Duration, hour
- 35. Accessories
 

Each transformers furnished with fittings and accessories as per T.S.

Approximate overall dimensions, mm Yes/No
- 36. a. Length
  - b. Breadth
  - c. Height
  - d. Crane lift for untanking core and coil assembly (including sling)

Approximates weights, Kg
- 37. a. Core and coil

- b. Tank and fittings
- c. Oil
- d. Total weight
- 38. Shipping data
  - a. Weight of the heaviest package, Kg
  - b. Dimensions of the largest package (LxBxH), mm

### 8.8 Insulators

- 1. Make
- 2. Type
- 3. Material of insulator
- 4. Colour
- 5. Insulation level:
  - Dry (PF)
  - Wet (PF)
  - Impulse
- 6. Creepage distance
  - a) Total (mm)
  - b) Protected (mm)
- 7. Power freq. Puncture test
- 8. Visible discharge test volt
- 9. Suitable to connect
- 10. For support insulators minimum height of base from ground
- 11. Number of disc in string insulators.
- 12. Rated voltage for disc in kV
- 13. Deviation if any from the data sheet.

### 8.9 ACSR Conductors/Aluminum Bus/IC, XLPE-Cable Bus

- 1. Make
- 2. Type
- 3. Size
- 4. Nominal current rating at maximum site ambient
- 5. Short time rating for 3 sec. (in kA)
- 6. Rated dynamic stability current kA (peak)
- 7. Weight per mtr in kg
- 8. Clearance
  - Phase to phase
  - Phase to earth

### 8.10 Supporting Structures

- 1. Make
- 2. Type
- 3. Material used Steel/RC
- 4. Thickness of galvanizing (for GI)
- 5. Designed for wind load
- 6. Designed for earth quack load
- 7. Matching with equipment arrangement Yes/No
- 8. Design calculation for sizing Will be are per approved calculations for each structure.

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>9. Scope of work</li> <li>10. Foundation bolts and base bolts (bolt shall be projected at least 75 mm above base plate</li> <li>11. Standard followed for fabrication of steel structures</li> <li>12. Approach ladder provision</li> <li>13. Deviation if any from technical specifications</li> </ul> | <p>Support for equipment, bus bars etc. as per approved layout included.</p> |
|--|--|

## **8.11 Earthing and Lightning Protection**

### **8.11.1 General**

Size of earth strip for the yard	
Gap between earth mat conductors	
Size of main outer strip	
Galvanizing content on above	
Value of earthing resistance (proposed to be achieved)	
Standard to be followed for galvanizing	
Type of electrodes	
Construction of earthing pit as per IS	Included

### **8.11.2 Lightning Protection**

Whether shield wires or lightning conductors have been envisaged for the lightning protection	
Angle of protection	
Whether s/s building is also protected	Yes/No
Numbers of electrodes provided	
Earthing resistance value	
Size of down conductors	
Standard followed	
Deviations if any on technical data sheet	