



## SECTION – 2.28

### AUXILIARY TRANSFORMER (DRY TYPE)

#### 1.0.0 INTRODUCTION

- 1.1.0 This section covers the requirements of outdoor dry type 11 kV transformer for MCR and BESS plant area shall be installed to power up the control circuit and plant auxiliaries.
- 1.2.0 The sizing of Transformer shall be as per Auxiliary load calculation with 10% design margin

#### 2.0.0 SCOPE OF WORK

- 2.1.0 The scope of work shall include the following equipment.
- 2.2.0 Required rating shall be designed as per connected load. Final rating shall be as per Standard Ratings as per IS.

#### 3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, IEC publications and any other standards of latest edition including amendments, except where modified and /or supplemented by this specification.

IS 2026	Specification for Power Transformers (All parts)
IS 2099	Specification For Bushings for Alternating voltages above 1000V
IS 3347	Dimension for porcelain transformer bushings
IS 3639	Specification For Fittings and accessories for Power Transformers
IS 4257	Porcelain Bushings for Transformers
IS 10028	Code of practice for selection, installation, and maintenance of transformers
IS-5	Painting
IS-2705	Specification for Current Transformers
IS 11171	Specification for dry-type power transformer
IS 8478	Application Guide for On Load Tap changers.
IS 10561	Application Guide for Power Transformers.



IS 1271	Electrical insulation - Thermal evaluation and designation
IS 1554(PART 1)	PVC insulated (heavy duty) electric cables, Part 1 For working voltage up to and including 1100V
IEC 60529	Ingress Protection of Enclosure of Transformer
IEC 60076	Power transformer
IEC 60905	Loading guide for Dry type transformer
IEEE C57.12.01-1988	Dry type Transformer
CBIP Manual on Transformers	
Indian Electricity Act and rules framed there-under.	
Regulations laid by the office of the Chief Electrical Inspector to Inspector to Central Electricity Authority (Draft Regulation on Technical standards for Construction of Electrical Plants and Electric Lines) Regulations, 2021/2022.	

#### 4.0.0 DRY TYPE TRANSFORMER

4.1.0 Transformers shall be designed with the maximum permissible winding temperature rise shall be 100 K for Class H insulation. The hot spot temperature shall not exceed the limits specified for the applicable insulation class in IEC 60076-11. The transformer shall be capable of continuous operation at rated load under the specified site ambient temperature without exceeding these limits

4.2.0 The transformers shall be capable of delivering the rated output at any particular tap continuously without exceeding the specified temperature limits under the following operating conditions.

- Voltage variation of  $\pm 10\%$  of rated voltage of that particular tap.
- Frequency variation of  $+3\%$   $-5\%$  of rated frequency.
- Combined voltage and frequency variation of 15% (absolute sum).
- The Aux. transformer losses
  - i. No Load Loss at rated voltage and frequency:  $<0.25\%$
  - ii. Full load loss at rated current at  $75^{\circ}\text{C}$ :  $<1.25\%$

4.3.0 The maximum flux density in any part of the core and yoke at the rated kVA, voltage and frequency shall be such that under 10% over-voltage condition, flux density shall not exceed 1.7 Tesla.



- 4.4.0 Dry Type AN cooled transformer shall be capable of operating according to IEC 60905 Loading guide for dry type transformer.
- 4.5.0 The transformers shall be free from hum and vibration when it is in operation, even at 110% rated voltage.
- 4.6.0 The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth to minimize interference with communication circuit.
- 4.7.0 The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding /through faults with full voltage maintained on other winding for a period of 2 seconds.
- 4.8.0 The transformer and all its accessories shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 seconds.
- 4.9.0 The transformer HV winding and bushing insulation shall be suitable for ungrounded system voltage (as determined by inverter output voltage).
- 4.10.0 The noise level of transformer, when energized at normal voltage and frequency, shall not exceed the limits specified in NEMA TR-1.
- 4.11.0 All leads and connections shall be mechanically strong, adequate insulated, protected against mechanical injury and rigidly clamped to withstand dynamic load.



## **5.0.0 CONSTRUCTIONAL FEATURES - DRY TYPE TRANSFORMER**

### **5.1.0 Windings**

- a) Windings shall be fully uniformly insulated. The high voltage shall be wound with high conductivity copper conductors and the insulation shall be done by Vacuum pressure impregnation process. The Current density shall not exceed 2.5A/Sq. mm for HV, LV windings at any tap. Coils shall be separated by a uniform air space that permits free circulation of cooling air between the coils. Windings shall be properly sized, insulated and supported for the voltages and currents to be encountered in operation, including short circuits. Insulation shall be class-H and temperature limited to class-F.

### **5.2.0 Core**

- a) The transformer core shall consist of thin, individually insulated sheets of high permeability, cold rolled grain-oriented, non-aging silicone steel. They shall be miter-corner-cut without burs, to provide a cross section most nearly resembling the circular cross-section. Laminations shall be cut and stacked utilizing step-lap construction to reduce losses and sound. Designed flux density shall be kept well below saturation. The assembled core shall be braced with heavy structural steel angle or channel to apply uniform clamping forces across the entire width, top and bottom. The core shall be protected from corrosion with high temperature rated rust-resistant coating.

### **5.3.0 Core and Coil Assembly**

- a) Construction shall consist of separate high and low voltage coils for each phase, mounted coaxially, with high/low air space between coils adequate for the rated voltage potentials. Coils shall be mounted concentrically and supported in place on the transformer core so as to restrain movement in shipping and in service.
- b) Each coil shall be supported on epoxy blocks, top and bottom, with resilient pads to retain the coils while permitting thermal expansion under loading. The core-and-coil assembly shall be designed and manufactured to withstand without damage the short circuit testing.
- c) All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.

### **5.4.0 Bus**

- a) All bus work shall be designed to withstand maximum short circuit stresses when connected to a supply system having a specified fault capacity, and to meet all test voltage requirements, without audible or visible corona. Low voltage bus shall be high conductivity copper. Connections of coil windings to bus shall be brazed or welded using shielded arc techniques designed to provide high joint integrity.
- b) Connection and terminal bolting surfaces shall be tin or silver-plated. Bolted connections shall include spring washers to maintain bolted surface pressure. All bus shall be sized to conform to industry standards and practices, for the amperes involved and maximum specified ambient temperatures.
- c) High voltage bus shall be high conductivity copper. It shall be supported by glazed porcelain insulators for surge strength. It shall have bolt-connected joint and terminal surfaces tin or silver-plated. High voltage leads shall be bus or flexible, insulated cable with industry-accepted types of terminations.
- d) Taps shall have flexible cable or solid copper links or jumpers. Ground bus shall be copper bus or comparable bare conductor extending the full length of the enclosure. It shall have provisions to mount appropriate terminal connections for adjacent switchgear or external grounding.



### 5.5.0 Enclosure

- a) The enclosure shall be a ventilated enclosure for outdoor use and be designed to provide adequate ventilation for the transformer.
- b) Protection of enclosure shall be at least IP 55. Screens shall be perforated sheet steel type. Mesh size shall be such that lizard, rats etc. cannot enter inside the enclosure.
- c) Double leaf access shall be provided with concealed hinge and neoprene gaskets for easy access to H.V. links and also for withdrawal of core and coil assembly if required. The enclosure shall be of CRCA sheet steel with a minimum thickness of 2 mm while the roof and vertical supports shall be formed from minimum 3 mm thick sheet steel. The enclosure shall be adequately reinforced to ensure rigidity so as to permit transportation of transformer within enclosure.
- d) All steel panels shall be cleaned, primed then epoxy painted with a finish coat as required for an outdoor installation. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized adequately. Each transformer shall be provided with one set of bidirectional rollers for rolling the transformer parallel to either centre line. Four nos. of heavy-duty eye bolt/lifting lugs suitable reinforces by vertical support shall be provided. Two nos. heavy duty eye bolt/lifting lugs for top cover of adequate size shall be provided.

### 5.6.0 Base

- a) The transformer base shall be a separate rigid steel weldment capable of supporting the core and coil assembly and enclosure.
- b) Construction shall include provisions for lifting as well as for jacking and skidding or rolling in both directions. Two steel ground pads with two tapped holes for attaching ground leads shall be provided, one in each diagonally opposite corner of the base. Lifting provisions shall be designed for lifting the transformer and the core-and-coil assembly, separately or together.

### 5.7.0 Temperature Indicators

- a) For measuring temperature in the winding PT-100 Resistance temperature detectors shall be embedded in all three phases in LV windings.
- b) Potential free alarm and trip contacts shall be provided in to operate alarm and trip circuits. 4 channel temperature scanner & Local winding temperature indicator for winding temperature measurement shall be provided in the marshalling box.

### 5.8.0 Safety Interlock

- a) For all dry type transformers following safety interlocks shall be provided:
  - A safety interlock shall be provided to ensure that the enclosure door can be opened only when transformer is de energized.
  - Safety limit switches operated by door handle shall be provided for tripping HV & LV side breaker.
  - Limit Switches
  - Minimum 4 Nos. Limit switches shall be provided for Transformer enclosure Door interlock. Each Limit switch shall have 1 NO & 1 NC contact. All NO contacts of limit switch shall be connected series and NC contacts shall be connected parallel.



### 5.9.0 Bushings

- a) The design of the bushing shall be such that stresses due to expansion and contraction in any part of the bushing shall not lead to its deterioration.
- b) All bushings shall be homogenous, non-porous porcelain type, uniformly glazed and free from blisters, burns and other defects complete with suitable terminal connectors of adequate capacity. The porcelain shall not engage directly with hard metal and, wherever necessary, gaskets shall be interposed between the porcelain and the fitting.
- c) 12kV Bushing shall be used, and all the bushing of same voltage class shall be interchangeable. Bushings located inside cable boxes / busduct flanges can be epoxy-molded types.
- d) Clamps and fittings of steel or malleable cast iron shall be galvanized. Bushing location shall provide adequate phase and ground clearances. Creepage distance of bushing shall be 31mm/kV.

### 5.10.0 Cable Box

- a) A dust tight air insulated type cable box with minimum IP 55 protection shall be provided for terminating the cables directly of size and type specified. Inspection cover for fixed portion of cable box shall be provided. Handles for lifting cable box shall be provided. The cable box shall have PRD.

### 5.11.0 Neutral Terminals

- a) Two (2) Nos. neutral terminals shall be provided on LV side. One neutral terminal shall be part of phase connection arrangement busduct throat/ LV cable-box (as applicable). Other neutral terminal shall be brought to the transformer bottom by means of earthing bar of 50x6 mm of copper, supported on insulators mounted on transformer body.
- b) The neutral earthing bar brought to the bottom for connection to station earth shall be provided with holes and suitable connecting hardware.
- c) Neutral bushing CT shall be provided as specified. CTs shall be cast resin type. CT shall be located before formation of 2 nos. terminals.

### 5.12.0 Marshalling Box

- a) The marshalling box shall be fabricated using sheet steel of at least 2 mm thickness. All doors, covers and plates shall be provided with neoprene gaskets. Marshalling box shall be complete with all internal wiring and identification ferrules, cables, conduits required for wiring between marshalling box and instruments on transformer.
- b) The marshalling box shall be provided with thermostatically controlled space heaters and shall have minimum IP:53 degrees of protection. CT terminals shall be with shorting and disconnecting facility. Cable gland plate shall be of removable type. The marshalling box shall have MCB for incoming power supply. Marshalling box shall have temperature scanner & Local winding temperature indicator for winding temperature measurement.
- c) Terminal block shall be provided in marshalling box to connect cabling between RTD's and Temperature scanner. The Temperature scanner shall have accuracy of  $\pm 1\%$  and the scanner shall be suitable to communicate with SCADA. The Temperature scanner unit shall continuously monitor the winding temperature and shall be provided with auxiliary relays, one for alarm and one for trip (Potential free contacts).
- d) The Marshalling box bottom shall be at least 600mm above floor level.



- e) All terminal blocks are stud type (screw driver operated) and wiring shall be carried with ring type lugs.
- f) Terminal blocks for CT shall be disconnecting type and with shorting provision.

#### **5.13.0 Wiring**

- a) All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
- b) PTFE Cable shall be provided for wiring of temperature scanner. For other applications, Wiring shall be done with 1100V grade PVC insulated FRLS wires in conduit or PVC insulated armoured multi strand FRLS cable. Minimum wire size shall be 2.5 sq. mm. stranded copper for control & 6 sq. mm. stranded aluminium or 4 sq.mm stranded copper for CTs. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.
- c) All devices and terminal blocks within the marshalling box shall be identified by symbols corresponding to those used in applicable schematic or wiring diagrams. Each wire shall be ferruled by plastic tube with indelible ink print at both end having terminal block no. terminal no. as per approved schematic or wiring diagrams.

#### **5.14.0 Grounding**

- a) Two grounding pads, located on the opposite sides, shall be provided for connection of station ground mat for each transformer.
- b) Grounding pads shall have clean buffed surface with tapped holes. M10 GI bolts, nuts and spring washers.
- c) The core coil assembly shall be directly connected to this ground bus by removable bolted link for effective grounding.
- d) Two ground terminals each shall be provided on marshalling box & cable box. For continuity of earth connection, all gasketed joints shall be provided with minimum two (2) nos. copper strip jumpers of adequate size.

#### **5.15.0 Nameplate**

- a) Each transformer shall be provided with a rating name plate. Plates shall be of weather-resistance (stainless steel) material fitted in a visible position.
- b) Rating/ Name plates shall be of white non-hygroscopic material with engraved black lettering. Such plates shall be scripted in English only. Alternatively, two separate plates with English inscription shall be provided.
- c) Following information should be mentioned in the name plate.
  - Type of Transformer
  - Governing Specification
  - Manufacture's name
  - Manufacture's serial number
  - Year of manufacture
  - Rated output
  - Rated frequency



- Highest voltage equipment
- Rated voltage.
  - Primary
  - Secondary
- Rated current.
  - Primary
  - Secondary
- Maximum temperature rise over an ambient of 50 deg.C. of winding.
- Total weight
- Class of insulation
- Insulation levels
- Connection diagram indicating the tap screen.

#### 5.16.0 Fittings and Accessories

- Each Dry type of transformer shall be supplied with the following as a minimum:

Sl.No	Items	Quantity
1	LV Busbar support epoxy insulators	1 lot
2	HV Bushing Epoxy	3 Nos.
3	HV Cable Box	1 No.
4	LV Busduct chamber	1 No.
5	Lifting angle for complete Transformer	1 set
6	Lifting lug and haulage lugs	1 set
7	Jacking arrangement for transformer (for transformer weighting above 3000 kg)	1 set
8	Sheet steel enclosure with louvers and Pad lock	1 No.
9	Inspection covers	1 lot
10	Bi-directional rollers with locking & bolting arrangement. Suitable arrangement for core and winding assembly to draw out the same.	1 set
11	Caution plates	2 Nos.
12	Limit switches	4 Nos.
13	LV neutral grounding insulators	1 set
14	Temperature Scanner	1 No.
15	Winding temperature indicators with solid state type temperature signaliser with digital read out and requisite sets of remote signalling contacts for alarm and trip operation.	1 No.
16	Earthing terminals with lugs	2 Nos.
17	Grounding pads for Cable box & Marshalling Box	1 set.
18	Marshalling box complete with accessories.	1 No.
19	Set of Interconnecting cables with cable glands & lugs	1 lot



Sl.No	Items	Quantity
20	Off circuit tap changer links with accessories in the primary side	1 No.
21	Rating plate and terminal marking plate	1 No.

The fittings listed above are only indicative and other fittings which generally are required for satisfactory operation of the transformer are deemed to be included. The transformer fittings and accessories shall be of reputed make and shall be subject to approval of the purchase.

#### 5.17.0 PAINTING

1. Painting shall be carried out as per 'CBIP Manual on Transformers'. Painting process shall be approved by the purchaser.
2. The final coat shall be of a glossy oil and weather resisting non-fading paint of shade number RAL 7035. The paint shall be suitable for the site condition. Primer paint shall be ready made zinc chrome as per IS: 104; intermediate and final coats of paint shall be as per IS:2932. The final thickness of paint film on steel shall not be less than 80 microns. Sufficient quantity of touch-up paint shall be furnished for application at site.
3. Any damage to paint work incurred during transport and erection shall be made good by the Vendor by thoroughly cleaning the damage portion and applying the full number of coats of paint that had been applied before the damage was caused. One coat of additional paint shall be given at site over all external surfaces, including hardware, after erection. Vendor shall supply the requisite quantity of paint.

#### 5.18.0 PACKING & DELIVERY

1. The Vendor shall arrange transportation of all equipment from the point of manufacture to the Site. The arrangements shall include, but not be limited to, hiring adequate capacity of Wagon, determination of routes, determination of required permits, payment of required taxes and duties, and notification to the Purchaser.

#### 6.0.0 TESTS

All tests shall be carried out using its own accessories and parts which shall be supplied along with the Transformers. Offered rating and type of transformer should have type tested. Test reports of short circuit test shall be submitted along with the offer. The charges for carrying out all routine tests shall be deemed to be included in the Bid price. The charge of carrying out each type test/ special test shall be given separately in "Schedule of Unit Rates" for price adjustment purpose, In case of waiver of any of the tests by the Purchaser at a later date.

##### 6.1.1 Type Tests

Following type tests shall be conducted in addition to routine tests on one of each type (rating) of transformer as per IS: 2026/ IEC-60076//CBIP Manual:

- Temperature rise Test.
- Power frequency voltage withstand test
- Lightning impulse test on line terminal
- Lightning impulse test on neutral terminal (for non effectively grounded neutral)
- Degree of protection for marshalling cabinet

##### 6.1.2 Routine Tests

Following routine tests shall be conducted on each transformer as per IS: 2026/ IEC-60076/CBIP Manual :



- Measurement of winding resistance
- Measurement of voltage ratio and check of phase displacement
- Measurement of impedance voltage / short circuit impedance ( principal tapping ) and load loss.
- Measurement of no load loss and current.
- Measurement of insulation resistance.
- Separate source AC withstand test
- Induced overvoltage withstand test
- Lightning impulse test on line terminal
- Lightning impulse test on neutral terminal(for non effectively grounded neutral)

**6.1.3 Following additional routine tests shall also be carried out on each transformer :**

- Magnetic balance test
- High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

**6.1.4 Special Tests**

Following Special tests shall be conducted on each transformer as per IS: 2026/ IEC-60076 /CBIP Manual:

- Determination of capacitance windings-to-earth, and between windings.
- Measurement of insulation resistance to earth of the windings, and /or measurement of dissipation factor (  $\tan \delta$  ) and capacitance of the insulation system at factory and before commissioning at site. Tan-Delta and capacitance parameters shall be within IEEE C57.152 standards.

**7.0.0 DEVIATION POINT**

7.1.1 Bidder shall furnish the list of deviation from the technical specification in his proposal. Unless or otherwise deviation list submitted it is understood that Bidder is fully in compliance with the Technical Specification mentioned herewith.

**8.0.0 DRAWINGS & DOCUMENTS**

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Transformer sizing calculation
- Technical data sheet
- Dimensional General Arrangement drawing of transformer and section drawing.
- Parts list
- Component list and Bill of Quantities
- Bushing / Terminal arrangement
- Cable box details
- Busduct termination arrangement
- Catalogues/drawings for bought out items.
- Transport /Shipping dimension drawing
- Foundation Plan & loading details
- Name plate details
- Dynamic short circuit test certificate / test report of similar transformer shall be provided. In case of DSC test certificate is not available; manufacturer shall carry out the test at no cost to the owner.
- Design calculations for short circuit withstand capability.
- Erection and commissioning procedures
- Operation and maintenance manual



- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan

#### 9.0.0 TECHNICAL PARAMETERS

SI. No.	Description	Unit	Data
1.	Service		Outdoor
2.	Type		Dry type, two winding
3.	No. of Phase		Three
4.	Rating	kVA	-
5.	No. of windings		Two
6.	Nominal system voltage (HV / LV)	kV	11/0.415 , 50 Hz
7.	Vector group		Dyn11
8.	Type of cooling		AN
9.	Impulse withstand level		
a)	HV side	kV	75
10.	One minute Power frequency withstand voltage		
a)	HV side	kV	28
b)	LV side	kV	3
11.	Connections		
a)	HV side		Delta
b)	LV side		Star
12.	Neutral Earthing		
a)	HV side		
b)	LV side		Solidly grounded
13.	Terminal arrangement		
a)	HV side		Cable Box
b)	LV side		Cable Box
a)	LV Neutral side		Ground conductor
14.	Bushings		
a)	Bushings Creepage distance		31 mm /kV
15.	Tap Changer		
a)	Type		
b)	Tap provided on		HV side
c)	Range of taps	%	+5% to -5% in steps of 2.5%
16.	Short circuit withstand duration	Sec	2
17.	Losses		
	Copper Loss		As per IS
	Iron Loss		As per IS
18.	Impedance		As required to limit fault level
19.	Winding Material		Copper