

**SPECIFICATIONS OF STATCOM TRANSFORMER**  
**(FOR 2.5 MVAR STATCOM)**

<b>PROJECT</b>	<b>: 2.5 MVAR STATCOM. The transformer will be used for connecting a 2.5 MVA Inverter with grid at 6.6 kV.</b>
<b>EQUIPMENT</b>	<b>: Transformer</b>
Quantity	: 1 No.
1. Primary Rating (at all taps)	: 3 MVA Continuous (Fundamental)
2. Frequency	: 50 Hz (Fundamental)
3. Vector group	: YNd11d11 HV Winding Star Connection LV Windings Delta Connection
4. HV Winding Voltage (L-L)	: 6.6 kV $\pm$ 10%, 3-phase
5. LV Winding Voltage (L-L)	: 2365 V (Fundamental)
<b>LV Winding Current</b>	<b>: Rating of each secondary winding is 1.5MVA. However, when only any one of the secondary winding is loaded, then that winding will be loaded to the maximum of <b>1.64MVA</b> (i.e. a secondary current of 400A) .</b>
6. Tapping on HT Windings	: $\pm$ 2.5 % , $\pm$ 5 % (Rated kVA on all Taps)
7. H.V. Neutral	: This will be the fourth terminal in HV cable box, and insulated to full line voltage including clearances and creepages. Current carrying capacity and size shall be same as line terminals.
8. Impedance , Tolerance	: 5% on principal tap ( Minimum) Tolerance + 10 % - 0 % Impedance of the both the secondary windings should be identical
9. Duty	: Inverter duty. The transformer secondary will be connected to a three-phase inverter with inductor of 0.15 PU inductance. The THD on inverter output voltage in operating range varies between 15 % to 25 %.
11. DC Component (mV)	: 160mV ( This is always present in the input supply of transformer. Transformer should be suitably designed.
12. Over-fluxing	: Transformer shall be suitable for 125% over fluxing at the time of STATCOM start-up (duration of 10 secs.)

13. Insulation : All windings to be uniformly insulated. The windings to be designed to BIL Level – 2 of IS 2026
14. Protection : The transformer should be provided with Buchholz relay. Other relevant protections as per BIS should be provided.
15. Current Transformers on HT side : Insulation Class of CT 6.6 kV  
 1) 2 nos. of 300 / 5 Amps , 10 VA , 5P10 Class on Line  
 2) 1 no. of 150 / 5 Amps , 10 VA , 5P10 Class on Neutral
- Current Transformers on LT side : Insulation Class of CT 3.3 kV  
 6 nos . of 600 / 5 Amps , 10 VA , 5P10 Class on Line.  
 (3 nos. of CT per each secondary winding)
16. Type of cooling : ONAN. Mineral oil filled
17. Installation : Outdoor duty (Under direct sunlight)
18. Ambient temp. : 55 Degree C
19. Temperature rise  
 (a) Design ambient temp. : 55 Degree C.  
 (b) Temp. rise of top of oil by thermometer : 50 Degree C.  
 (c) Temp. rise of wdg. by resistance method : 55 Degree C
20. Relative Humidity : 100 %
21. Short Ckt. level at 6.6 kV : 300 MVA
22. Suitability to withstand : The transformer should be designed to withstand vacuum breaker switching on HT side
23. Transformer Material  
 a) Material of winding : Copper – Electrolytic Grade  
 b) Core : Not to exceed  $1.3 \text{ Wb/m}^2$  at any tap position with  $\pm 10\%$  voltage variation from voltage corresponding to the tap. The laminated core shall be of high grade cold rolled grain oriented silicon steel.  
 c) Tank : Tank shall be of welded construction and fabricated from tested low carbon steel. It shall be designed for a continuous internal pressure of 0.35 Kg/sq. cm over normal hydrostatic pressure of oil. **The tank cover shall be sloped to prevent retention of rain water.** All bolted connections shall be fitted with weather proof hot oil resistant neoprene gasket, in between for complete oil tightness. Calculation for pressure test shall be submitted. Bi – directional skids, rollers, jacking pads( four nos), lifting lugs shall be provided.  
 d) Hardware : All nuts and bolts exposed to weather shall be hot dip galvanised or cadmium plated or zinc passivated steel.

24. Overall Dimensions : The overall transformer dimensions should be within the dimensions of 3700 (L) X 2700 (B) X 3100 (H). The floor area should not exceed (3700 (L) X 2700 (B) ). HT and LT terminals should be mounted on 2700mm side of the transformer. All dimensions are in mm.
25. Noise : Not to exceed values specified in NEMA TR –1
26. Insulating oil : Fresh oil (before pouring into transformer) should be as per IS 335, without inhibitor. 10% extra oil shall be supplied for top ping in non returnable containers in sealed drums.
27. Construction : Earth screen to be provided between primary and secondary side. Since the transformer is used for converter duty. Since the transformer is used for converter duty, it should be 3 legged core, 5 legged core is not allowed.
28. Terminal arrangement : Suitable for termination of XLPE cable with Raychem type heat shrinkable terminating kits on HT side and LT side. 4mm thick Aluminum blank (undrilled) gland plates to be supplied with H.T., L.T. and Mar-shalling boxes. Bushings of Porcelain confirming to IS 2099 & IS 3347. The minimum length between cable gland plate and cable lug to be 550 mm for both H.V. and L.T. side cable boxes. Terminal marking shall be as per IS 2026. Epoxy bushings are not acceptable. Terminals to be threaded or Plug type
29. Tap changer : OFF circuit tap changer with padlocking facility as per IS 2026 with warning plate  
" SWITCH TO BE OPERATED WITH  
TRANSFORMER DE-ENERGISED"
30. Painting (Transformer and accessories) : Polyurethane
31. Shade : 631 as per IS 5
32. Fittings and accessories : As per Annexure-A
33. Standards : IS 2026
34. Testing (Routine Tests) : As per Annexure – B
35. Quality plan : Supplier should submit his Quality Plan for approval (Post Ordering stage)
36. Testing (Type Tests) : As per Annexure - B . Procedure as per IS 2026
37. No load loss & Load loss : Guaranteed maximum values without any positive tolerance shall be given with the offer.

An amount of Rs. 15000/- per KW of differential copper loss and Rs.60,000/- per KW of differential iron

loss will be levied on the manufacturer, if these losses exceed the guaranteed losses quoted. For the bid comparison purpose, price loading will be done at above rates for losses.

38. Data Sheet : DATA SHEET is enclosed with this specification. The same is to be filled up and submitted along with the technical offer.
39. Information Req'd. with the offer : (a) Filled up data sheet (Annexure – C)  
(b) Deviations to this specification. If there are no deviations, supplier must mention the same explicitly in their technical offer.  
(c) Unpriced prebid must be enclosed with technical offer. Price bid must contain list of type tests with individual charges and also price for individual items in list of spares  
(d) Supplier to give charges for individual type tests.  
(e) Supplier to furnish item wise price for list of spares.  
(f) Short description on the construction of core, and disposition of windings in the transformer.
40. Information required after order placement : Outline GA Drg. showing weights, dimensions, foundation plan and List of Accessories. Drawing along with design summary should be submitted for approval
41. Document to be submitted : (a) Operation and Maintenance manual.  
(b) Test Certificates for Routine & Type tests, and guarantee Certificates.  
(c) Guarantee Certificate

NOTE:

1. The test charges for each type test must be mentioned test wise in the price bid. However, a confirmation to that effect must be contained in the technical offer. Unpriced copy of price bid must be enclosed in Technical offer.
2. Once the order is placed, the supplier should submit design calculations for approval for the purpose of the conformity of the designed transformer for inverter duty.
3. The transformer has to be tested in presence of BHEL engineers for dispatch clearance.

For any Technical Clarifications, please contact :

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## ANNEXURE - A

All accessories shall be provided confirming to IS 3639. The following fittings and accessories shall be provided:

<u>SL.NO</u>	<u>DESCRIPTION</u>	<u>QTY</u>
01.	Oil filling hole with cover	1
02.	Conservator with sump & drain valve with plug/cover plate. The Breather shall be mounted at a height less than 1600 mm from the ground.	1
03.	a) Magnetic Oil level gauge(Dial type) with minimum and maximum filling level markings. It should have two independent electrically insulated low level alarm contacts suitable for 220 V DC. The oil level at 30 deg C shall be marked on the gauge. Contact suitable for 220 V DC.	1
	b) Prismatic oil level gauge	1
04.	Thermometer pockets	1
05.	Air release plug on tank cover	1
06.	Lifting lugs	1 SET
07.	Top filter valve	1
08.	Dehydrating breather with Silica gel and oil seal	1
09.	Off circuit tap changing switch on tank cover with tap position indicator, locks and handle.	1
10.	Rating and terminal marking stainless steel/anodised aluminum plate, with details etched in MKS & SI units.	1
11.	Earthing terminals without lugs suitable for connecting 50x6 mm galvanized mild steel flat.	2
12.	Diagram plate	1

13.	Drain cum bottom filter valve	1
14.	Base channel with towing holes/lugs	2
15.	Four Jacking Pads to enable transformer with oil to be raised or lowered using hydraulic or screw jacks.	1 SET
16.	Manufacture's name plate (stainless steel)	1
17.	Bi-directional rollers + Bi-directional skids	1 SET
18.	Detachable radiator with bottom drain plug, top air release plug and top & bottom shut off valve.	1 SET
19.	Buchholtz relay should be of double float type with testing & sampling cocks, alarm and trip contacts and one isolating valve on conservator side	1 SET
20.	150mm dial type oil temp. Indicator and winding temp. Indicators with max. pointer with alarm and trip contacts. Contacts suitable for 220V DC. Indicator accuracy $\pm 2\%$ . Alarm and trip points to be adjustable. Full scale temp. 240 deg C. Least count 2 deg C. Oil / Winding temp. Indicators should be provided with resetting device.	1 SET
21.	Cable glands & lugs Cable sizes shall be informed at the time of drawing finalisation. Cable lugs shall be of tinned copper for crimping to stranded aluminum conductor cable. Cable glands will be of double compression type.	1 SET
22.	Marshalling box (protection class IP55 and IS 2147) epoxy painted. Should be vermin, weather, dust proof. Terminal connector of control cable should be DOWELL make or equivalent. 20% extra spare terminals reqd. All TBs to be complete with insulating barriers, clip on type terminals suitable to 2.5 sq mm stranded copper wire. The marshaling box and temperature indicators shall not be mounted at a height greater than 1600 mm from the ground level. The box shall be tank mounted with sloping roof. All incoming cables shall enter from bottom. Sheet steel to be 1.6 mm thick. Thermostatically Controlled space heaters shall be provided.	1 No
23.	Inspection openings on tank with handles	2 Nos.
24.	Remote WTI – For Remote Control Panel It shall not be a repeater dial of Local WTI	1 No.

NOTE :1) Contacts of all temp indicators, Buchholz relays and auxiliary devices shall be suitable for 220 V dc supply. All alarm and trip contacts shall also be suitable for 220 V dc circuits. External power supply will not be provided.

- 2) Nuts and bolts exposed to weather to be hot dipped galvanized or cadmium plated or zinc passivated steel.
- 3) Control wiring to be done with 1100 V grade PVC LV Winding Delta Connection wire, 2.5 mm stranded copper wire.
- 4) Cable glands and lugs shall be supplied loose along with transformer. See Pt 22. Cable glands will be double compression nickel plated brass. Cable lugs will be installed with fixing hardware in the cable box.

**ANNEXURE - B**

**B) Final testing of Finished Transformer**

The following tests shall be conducted on the finished transformer.

- Routine tests in accordance with the latest issue/ amendments of IS 2026
- Magnetic Balance Test

The following type tests shall be conducted on the transformer.

- Temperature rise test as per IS2026 with latest amendments.
- Full wave Impulse test on HV wdg, LV windings. Voltage peak shall be as per list 2 of IS 2026,

**Note : (i) Supplier shall submit price for each type test test-wise in the offer.**

DATA SHEET

- 1) Manufacturer's Name and address :
- 2) Service Class / KVA rating :
- 3) Rated Voltage
  - a) HV Winding KV :
  - b) LV Winding KV :
- 4) Rated frequency :
- 5) Number of phases :
- 6) Connections
  - a) HV Winding :
  - b) LV Winding KV :
- 7) Connection symbol :
- 8) Type of cooling :
- 9) Tap changing equipment
  - a) Manufacturer :
  - b) Type :
  - c) No of steps :
  - d) Tap range % to % :
- 10) Guaranteed positive sequence impedance at 75 deg C with 100% rating
  - a) Principal tap :
  - b) Maximum tap (Approx) :
  - c) Minimum tap (Approx) :
- 11) Temp. rise over an ambient of 50 deg C
  - a) Top oil deg C :
  - b) Winding(by resistance measurement method deg C ) :
- 12) Guaranteed losses at rated voltage on principal

tap and at rated current rated frequency:

- a) No load loss KW \* } SEE NOTE BELOW
- b) Copper loss at full load and 75 deg C KW \* }
- 13) Withstand time for three phase short circuit at terminals (sec.) :
- 14) No load current at rated voltage and rated frequency (Amps) (Approx) :
- 15) Insulation level
  - a) Separate source power frequency voltage withstand
    - i) HV Winding (KV rms) :
    - ii) LV Winding (KV rms) :
    - iii) HV Bushing :
    - iv) LV Bushing :
    - v) Neutral Bushing :
  - b) Induced over voltage withstand
    - i) HV Winding (KV rms) :
    - ii) LV Winding (KV rms) :
  - c) Full wave lightning impulse withstand
    - i) HV Winding (KV) :
    - ii) LV Winding (KV) :
    - iii) HV Bushing :
    - iv) LV Bushing :
    - v) Neutral Bushing :

**\* NOTE : LOSS FIGURES TO BE GIVEN WITHOUT ANY POSITIVE TOLERANCE. THESE FIGURES WILL BE USED FOR BID COMPARISON PURPOSE.**

- d) Switch impulse withstand voltage
  - i) HV Winding (KV) :
  - ii) LV Winding (KV) :
  - iii) HV Bushing :

:

- 16) Regulation at full load at 75 deg C
- a) At unity power factor (percent) :
  - b) At 0.8 power factor (percent) :
- 17) Terminal arrangement
- a) High Voltage :
  - b) Low Voltage :
  - c) LV Neutral :
  - d) HV Neutral :
- 18) Over excitation withstand time (sec)
- a) 120% :
  - b) 150% :
- 19) Bushing
- a) High Voltage
    - i) Manufacturer :
    - ii) Type :
    - iii) Minimum creepage distance(mm) :
  - b) Low Voltage
    - i) Manufacturer :
    - ii) Type :
    - iii) Minimum creepage distance(mm) :
  - c) Neutral
    - i) Manufacturer :
    - ii) Type :
    - iii) Minimum creepage distance(mm) :
- 20) Proposed method of transformer shipment :
- 21) Total quantity of oil (litres) required for first filling :
- 22) Is vacuum filling required, if so, state absolute pressure :

- 23) Efficiency at 75 deg C at unity power factor
- a) At full load ( percent ) :
  - b) At 3/4 full load (percent) :
  - c) At 1/2 full load (percent) :
- 24) Approximate dimensions
- a) Tank enclosure (mm) :  
L x B x H
  - b) Overall L x B x H (mm)
  - c) Limiting dimensions confirmed as in pt 37 of spec: YES / NO
- 25) Untanking height (mm) :
- 26) Approximate weight
- a) Core and winding (Kg) :
  - b) Tank cover (Kg) :
  - c) Tank fitting (Kg) :
  - d) Oil (Kg) :
  - e) Total weight (Kg) :
- 27) Despatch details (Kg)
- a) Approximate mass of heaviest package (Kg) :
  - b) Approximate dimensions of largest package
    - i) Length (mm) :
    - ii) Breadth (mm) :
    - iii) Height (mm) :
- 28) Reference standards :
- 29) Type of Construction (Core/Shell) :
- 30) Thermal time constant (Hours) :
- 31) Magnetizing inrush current (Amps)

- 32) No load current at rated frequency and at(Approx)
  - i) 90% voltage (Amps) :
  - ii) 100% voltage (Amps) :
  - iii) 110% voltage (Amps) :
- 33) Power factor of no load current :
- 34) Zero sequence impedance at principle tap :
- 35) Capacitance between winding and to earth (micro farads) :
- 36) Percentage reactance at rated current and frequency and at
  - i) Principal tap :
  - ii) Maximum tap :
  - iii) Minimum tap :
- 37) Off circuit tap changer details
  - a) Ratings
    - i) Rated voltage :
    - ii) Rated current :
    - iii) Step voltage :
    - iv) Numbers of steps :
- 38) Radiator
  - i) Overall dimensions lxbxh (mm) :
  - ii) Total weight with oil (Kg) :
  - iii) Total weight without oil (Kg) :
  - iv) Type of mounting :
  - v) Thickness of Radiator tube(approx) radiator sheet steel (approx) :

39) Weight of Transformer

- a) Core (Kg) (approx) :
- b) Windings
  - i) HV (Kg)(approx) :
  - ii) LV (Kg) :
- c) Insulation (Kg)(approx) :
- d) Tank/enclosure and fittings (Kg) :
- e) Oil (kg) :
- f) Untanking weight (Heaviest weight) (Kg) :
- g) Total weight (Kg) :

40) Dimensions

- a) Tank enclosure (mm) :  
L x B x H(approx)
- b) Overall L x B x H (mm) :

41) Shipping details

- a) Weight of heaviest package (Kg) :
- b) Total shipping weight (Kg)(approx) :
- c) No. of packages :
- d) Dimensions of largest package (mm) l x b x h :
- e) Parts detached for transport: conservator tank, radiator, eq.pipe, explosion vent etc. :

42) Size of filter hose (mm) :

43) Core

- a) Form of core :
- b) Net core area (mm<sup>2</sup>) :
- c) Type of joint between core and yoke :
- d) Thickness of stamping (mm) :
- e) Percentage silicon content (percent) :

- f) Maximum flux density in core at rated frequency and at
  - i) 90% voltage (Wb/m<sup>2</sup>) :
  - ii) 100% voltage (Wb/m<sup>2</sup>) :
  - iii) 110% voltage (Wb/m<sup>2</sup>) :
- g) Type of core binding :

44) Winding

- a) Type of winding
  - i) HV :
  - ii) LV :
- b) Current density at rated load
  - i) HV (A/mm<sup>2</sup>) :
  - ii) LV (A/mm<sup>2</sup>) :
- c) Conductor area
  - i) HV (A/mm<sup>2</sup>) :
  - ii) LV (A/mm<sup>2</sup>) :
- d) Maximum current density under short circuit
  - i) HV (A/mm<sup>2</sup>) :
  - ii) LV (A/mm<sup>2</sup>) :

45) Clearance

- a) Minimum clearance between phase
  - i) In oil (mm) :
  - ii) In air (mm) :
- b) Minimum clearance of HV winding to tank/enclosure (in oil, if applicable),(mm) :
- c) Minimum clearance of HV winding to earth (In oil, if applicable),(mm) :
- d) Clearance between core and coil (mm) :
- e) Clearance between coils (mm) :

46) Tank/enclosure details

- i) Side (mm) :
- ii) Bottom (mm) :
- iii) Cover (mm) :

47) Insulation levels

- |                         | <b>HV</b> | <b>LV</b> |
|-------------------------|-----------|-----------|
| i) Power Frequency :    |           |           |
| ii) Lightning Impulse : |           |           |

48) Bushings

- |                          | <b>HV</b> | <b>LV</b> |
|--------------------------|-----------|-----------|
| i) Type :                | Porcelain | Porcelain |
| ii) Rated Voltage :      |           |           |
| iii) Lightning Impulse : |           |           |
| iv) Creepage distance :  |           |           |
| v) Power Frequency :     |           |           |

49) Magnetic Oil Level Gauge :  
(Dial type) Size

50) List of deviations ( if any )enclosed : YES / NO  
enclosed with offer. If no deviations please mention  
the same here.