

Annexure - 9 (Reactor ETC)

handling, transportation, installation and service including line-to -line and line-to -ground faults.

20.15 Full details of the winding clamping arrangements, and their adjustment in or out of the tank together with relevant drawings and values, shall be submitted for evaluation and approval and shall form part of the instruction manual.

Current carrying connections

20.16 The design of all connections shall be subjected to Design Review.

20.17 The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts.

20.18 All lugs for crimping shall be of the correct size for the conductors.

20.19 Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

Winding terminations into bushings

20.20 Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the reactor in service.

20.21 The winding-end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remain intact during repeated work in this area.

20.22 Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.

20.23 In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends into the termination surfaces of the bushing.

20.24 Suitable inspection and access facilities into the tank in the bushing oil end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

21.0 Unused inhibited Insulating oil :

21.1 The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified below, while tested at supplier's premises. The

contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned below, prior to despatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer / reactor and only thereafter be brought up to the specified parameter by circulation within the transformer/reactor.

Sl. No.	Property	Test Method	Limits
A1.	Function		
1a.	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm ² /s
1b.	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)12 mm ² /s
1c.	Viscosity at -30degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)1800 mm ² /s
2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3.	Pour point	ISO 3016 or ASTM D97	(Max.)- 40degC
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814 or ASTM D1533	(Max.) 30 mg/kg 40 mg/kg
5.	Electric strength (breakdown voltage)	IEC 60156 or ASTM D1298	(Min.) 50 kV(new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	ISO 3675 or ISO12185 or ASTM D 4052	0.820 - 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90 deg C	IEC 60247 or IEC 61620 Or ASTM D924	(Max) 0.0025
8.	Resistivity at 90 deg C	IEC 60247	150 X 10 ¹² Ohm –cm, (Min.)

9.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
10.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 or ASTM D 2140	Max.Aromatic : 4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
B1.	Refining / Stability		
1.	Acidity	IEC 62021-1 or ASTM D974	(Max) 0.01 mg KOH/g
2.	Interfacial tension at 27degC	ISO 6295 or ASTM D971	(Min) 0.04 N/m
3.	Total sulfur content	BS 2000 part 373 or ISO 14596 or ASTM D129	0.15 % (Max.)
4.	Corrosive sulphur	IEC 62535	Non-Corrosive on copper and paper
		ASTM D1275B	Non-Corrosive
5.	Presence of oxidation inhibitor	IEC 60666 or ASTM D2668 or D4768	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives .Supplier should declare presence of additives, if any.
6.	2-Furfural content	IEC 61198 or ASTM D5837	25 Microgram/litre (Max.)
C1	Performance		
1	Oxidation stability -Total acidity -Sludge - Dielectric dissipation factor (tan delta) at 90degC	IEC 61125 (method c) Test duration 500 hour IEC 60247	Max 0.3 mg KOH/g Max 0.05 % Max 0.05
2.	Gassing	IEC 60628A or ASTM D2300	No general requirement

3.	Oxidation stability (Rotating Bomb test)	IEC : 61125(Method B) / ASTM D2112 (e)	220 Minutes (Min.)
D1.	Health, safety and environment (HSE)		
1.	Flash point	ISO 2719	(Min.)135degC
2.	PCA content	BS 2000 Part 346	Max 3%
3.	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)

21.2 i) Prior to filling in main tank at site and shall be tested for

1. Break Down voltage (BDV) : 70kV (min.)
2. Moisture content : 30 ppm (max.)
3. Tan-delta at 90 °C : Less than 0.01
4. Interfacial tension : More than 0.035 N/m

ii) Prior to energisation at site oil shall be tested for following properties

& acceptance norms as per below generally in line with IS: 1866 / IEC

60422 :

1. Break Down voltage (BDV) : 70 kV (min.)
2. Moisture content : 10 ppm (max.)
3. Tan-delta at 90 °C : 0.01 (max.)
4. Resistivity at 90 °C : 6×10^{12} ohm-cm (min.)
5. Interfacial tension : 0.035 N/m (min.)
6. *Oxidation Stability (Test method as per IEC 61125 method C, Test duration: 500hour for inhibited oil)
 - a) Acidity : 0.3 (mg KOH /g) (max.)
 - b) Sludge : 0.05 % (max.)
 - c) Tan delta at 90 °C : 0.05 (max.)
7. * Total PCB content : Not detectable (2 mg/kg total)

* For Sr. No. 6 & 7 separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of purchaser.

21.3 At manufacturer's works the quality of oil used for first filling, testing and impregnation of active parts shall meet at least parameter as mentioned in serial no. 1 to 5 of clause 21.2 ii) above. The oil test results shall form part equipment test report.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. For ONAN/ONAF cooled transformers / reactors, sample shall not be taken earlier than 2 hours after shut down.

The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

21.4 Particles in the oil

The particle analysis shall be carried out in an oil sample taken after completion of the oil purification at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength".

21.5 Moisture content in the solid insulation

Bidder may follow either method-1 or method-2 below to ensure dryness of solid insulation

Method-1: An Oil/ paper moisture equilibrium chart shall be applied for the analysis of the moisture-in-oil results obtained from an oil sample taken after complete winding drying and oil filling in the tank at site. In order to ensure that equilibrium conditions are properly assessed, the sample shall be taken not earlier than 7 days after completing the oil and impregnation treatment. Recording the temperature of transformer oil during sampling is essential.

With this sample it shall be demonstrated that the moisture content in the paper insulation body of the reactor is less than at least 0.5%.

Method-2: Dummy insulation test block shall be inserted in the active part of reactor at factory and same shall be used to detect the volume moisture content.

Before application of vacuum and oil filling in the reactor, it will be ensured that moisture content in the dummy insulation test block is less than 0.5%.

Oil filling

21.6 Procedures for site drying, oil purification, oil filling etc shall be submitted for approval and complete instructions shall form part of the manual.

21.7 The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method but shall generally not be less than 72 hours. The vacuum shall be measured on the top of the reactor tank and should be less than 1mbar.

21.8 Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the reactor is oil filled up to the Buchholz relay. Whenever the active insulation or any paper insulated HV connections, especially those from the windings to the bushings are exposed, these shall be re-impregnated under vacuum along with the complete reactor. For this purpose the reactor shall first be drained to expose all insulation material.

21.9 The minimum safe level of oil filling (if different from the Buchholz level) to which the reactor shall be oil filled under vacuum, shall be indicated in the manual.

21.10 The Ultra High Vacuum type oil treatment plant of suitable capacity (preferably 4500 to 6000 litres per hour) suitable for treatment of oil in EHV class reactor shall be used in order to achieve properties of treated oil.

The plant shall be capable of treatment of new oil (as per IEC 60296 and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow :

(i) Removal of moisture from 100 ppm to 3 ppm (max.)

(ii) Removal of dissolved gas content from 10% by Vol. To 0.1% by vol

(iii) Improvement of dielectric strength break down voltage from 20 to 70 KV

(iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.

(v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.

(vi) Processing temperature shall be automatically controlled and have a adjustable range from 40°C to 80°C

22.0 Terminal Arrangements

Bushings

22.1 The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/ DIN 42530.

22.2 Bushing for voltage of 800 kV shall be of porcelain type and hermetically sealed Oil filled condenser type.

Bushing for voltage of 145 kV shall be of the hermetically sealed Oil filled condenser type/ RIP bushing with porcelain or composite insulator.

22.3 Oil filled condenser type bushing shall be provided with at least the following fittings.

(a) Oil level gauge

(b) Tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

22.4 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

22.5 Bushings of identical rating shall be interchangeable. Further, 800 kV class bushings for autotransformers and shunt reactors shall be interchangeable to optimise the requirement of spares.

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

22.7 Clamps and fittings shall be of hot dip galvanised steel or of stainless steel.

22.8 Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

22.9 No arcing horns shall be provided on the bushings.

22.10 Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement

37.0 Inspection and Testing at Site

The Contractor shall carry out a detailed inspection and testing programme for field activities, namely covering areas right from the receipt of material stage up to commissioning stage. It is Contractor's responsibility to draw up and carry out such a programme duly approved by the Purchaser. Testing of oil sample at site shall be carried out as per Cl. 4.3.4 above.

21.0

38.0 Receipt and Storage Checks

38.1 Check and record condition of each package, visible part of the reactors etc. for any damage

38.2 Check and record the gas pressure in the reactor tank as well as in the cylinder.

38.3 Visual check for wedging of core and coils before filling up with oil and also check for condition of core and winding in general.

38.4 Check and record reading of impact recorders at receipt and verify the allowable limits as per manufacturer's recommendation.

39.0 Installation Checks

39.1 Check the whole assembly for tightness, general appearance etc.

39.2 Oil leakage test

39.3 Leakage check on bushing before erection.

39.4 Measurement of capacitance and tan delta of the bushings before

Fixing/connecting to the reactor. Contractor shall furnish these values for site reference.

39.5 Measure and record the dew point of gas in the main tank before assembly.

40.0 Commissioning Checks

40.1 Check the colour of silica gel breather.

40.2 Check the oil level in the breather housing, conservator tank, cooling system, condenser bushing etc.

40.3 Check the bushings for conformity of connection to the line etc.

40.4 Check for correct operation of all protection devices and alarms.

- (a) Buchholz relay
- (b) Excessive winding temperature
- (c) Excessive oil temperature
- (d) Low oil flow
- (e) Low oil level indication

40.5 Check for adequate protection of electric circuit supplying the accessories.

40.6 Insulation resistance measurement for :

- (a) Control wiring
- (b) Main winding
- (c) Bushing current transformer

40.7 Two kV/minute test between bushing CT terminal and earth.

40.8 Check for cleanliness of the reactor and the surrounding.

40.9 Measure vibration and noise level

40.10 DGA of oil sample just before commissioning and after 24 hours of commissioning.

40.11 Capacitance and tan delta measurement of winding & bushing.

40.12 Frequency Response Analysis (FRA). FRA equipment shall be arranged by purchaser.

40.13 Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Purchaser for future record.

41.0 FIRE PREVENTION SYSTEM BY INJECTING NITROGEN GAS

41.1. All the transformers shall be provided with fire prevention system by injecting Nitrogen gas.

41.2 Technical specification

41.2.1. The fire prevention system shall protect the oil filled power/auto transformer against explosion fire that may emanate internally (during internal fault etc) and /or externally (such as failure of condenser bushing of the transformer under subject, other source of equipment etc).

41.2.2. The system may be an integral part of the transformer and of leak proof.

41.2.3. The system shall be of automatic operation in sensing and taking Prevention measures in protecting the transformer whenever internal/external fire risk arises.