1.0 Overhauling of a transformer is normally undertaken either if it is faulty (internal) or at the end of 10 - 12 years of its service by way of periodic maintenance. It is advisable to review and analyze the periodical DGA values to check any abnormal variation and healthiness of the transformer. The procedure for periodic overhauling of transformer dealt herewith is applicable for bell type tank construction transformers. Periodical overhauling (POH) of transformer can be done either at site (TSS) or in traction repair shop or through trade. In case overhauling is undertaken at TSS, Railways shall construct a temporary shed of asbestos or tarpaulin after removing bell tank so that the dust is not ingressed by the active parts of the transformer during overhauling. In case overhauling is done in traction repair shop or through trade, the active part shall be kept under cover to protect the same from dust. The transformer should not be opened during rainy /cloudy weather for inspection/repair/overhaul.

2.0 TESTS PRIOR TO UNDERTAKING POH

Following tests shall be conducted on traction transformer before undertaking POH.

a) Measure dielectric strength (BDV), acidity, water content (ppm) & tan delta of transformer oil.
b) Dissoved gas analysis (DGA) of transformer oil.
c) Measurement of winding resistance on all taps.
d) Measure the insulation resistance of winding and polarization index.
e) Measurement of tan delta and capacitance of condenser bushing.

Insulation resistance & polarization index of the windings and BDV, acidity & DGA of transformer oil and the values of various tests shall be recorded. The same shall be compared with the values recorded after the completion of overhauling.

3.0 STEPS FOR OVERHAULING

3.1 UNTANKING OF TRANSFORMER

Before commencing the work, drain out the oil, disconnect all leads and remove manhole covers, accessories, conservator,breather, radiator, fittings, HV, LV bushings and store them in a safe place. One set of gaskets of standard quality shall be available for replacement during POH. The bell tank shall be removed by suitable crane/winch carefully so that the bell tank does not damage the active parts during dismantling. Defects observed during inspection/ test schedule for the subject transformer shall be recorded and taken into account and defects like leakage in tank, conservators and radiators etc. shall be attended and rectified permanently during POH of transformer.

3.2 ITEMS TO BE CHECKED / ATTENDED

Following items are required to be checked/ attended during overhauling:

S. No.	Items to be checked/attended	Action required.
1.	Insulating oil of the transformer main tank	The insulating oil has to be checked/tested as per IS: 1866-2000 and its replacement has to be done on its condition basis. Summarized guidelines of IS: 1866-2000 are given in a table at Annexure II.
2.	Transformer windings & internal parts of transformer and tank.	The sludge on the bottom of the tank, windings and interspaces between windings should be scrapped carefully by wooden or fibre wedge without causing any damage to the windings. Traces of the sludge left in inaccessible places are removed by hot oil jets. The old surface contamination should be brushed out and washed down untill clean surface of the winding is exposed.
3.	Conservator, radiators and other metal parts including associated pipes.	These shall be cleaned with hot oil jet to remove any traces of sludge.
4.	Check the drain valve, oil-sampling valve, filter valves etc.	Polish the valve seat and renew the gasket around the spindle for oil tightness.
5.	Check insulation blocks, permaliwood packing, spacers, wedge and keyed blocks and insulating rings with securing arrangement in the winding for their displacement due to frequent & repeated short circuit during service.	In case any said part/block is shifted, the same may be realigned and refixed using the adhesive compatible to transformer oil.
6.	Check the pressure screws with belleville washers and pressure cup for its intactness along with permaliwood packing.	Pressure screws with belleville washers shall be tightened in case found loose, In case pressure screws or cup and other item are displaced the same shall be attended and aligned or changed.
7.	Check the top and bottom yoke bolts and check ferrule insulation tube and dielectric strength by 2kV ac for 1 minute.	Tighten the yoke bolts in case loose. Replace the insulation ferrule if damaged.
8.	Check electrical joints, earth connections, between core to core & tank, lead connections for tap changer and transformer for tightness and intactness.	All the electrical connections shall be properly cleaned and tightened in case found loose. In case of damage to the leads and contacts they should be replaced by a new one.
9.	Check clearances of the active part form the tank body.	Clearance shall be maintained 100 mm for bare parts and 50 mm for insulated parts from the tank/earth surface.

10.	The contacts of off-circuit tap changer.	The contacts are to be cleaned properly and tightened. Any damaged contacts are to be replaced. After contact repair/cleaning/replacement its alignment should be made.
11.	Check the operation of off- circuit tap changer..	Operation shall be smooth and it shall indicate correct tap position on indicator.
12.	Check the tightness of all fasteners, Core bolts and core with tank fasteners etc.	Retighten them properly in case required.
13.	Check the condenser bushing for correct oil level, crack and leakage, if any.	In case of oil filled bushing it is recommended to remove the old oil from the bushing and fill fresh oil for better result. In case of oil sealed bushing if oil level is below the minimum level indicator, the manufacturer of the bushing shall be contacted for corrective action. Tan delta (max. 0.007) and capacitance of the bushings shall be compared with earlier test values. In case of major deviation of the values, the manufacturer of bushing shall be contacted. IR value of the bushings shall be more than 10,0000 M Ohm and BDV of oil shall be more than 50 kV.
14.	Transformer tank, conservator, radiators, pipe work and other associated parts.	All steel surfaces exposed to weather shall be properly descaled. The epoxy and polyurethane protective paints as per ISO/EN 12944 have to be provided for proper protection against corrosive and coastal environments and give life of approx. 12-15 years. All the external surfaces of the Transformer shall be given first coat of epoxy zinc rich (having minimum 83% metallic zinc) primer (50 micron thickness), intermediate coat of epoxy chemical and corrosion resistant High Build Epoxy Intermediate paint (100 micron thickness) and final coat of Glossy Aliphatic Acrylic Polyurethane Coating paint (50 micron thickness). The total dry film thickness of the paints shall be minimum 200 micron. The shade of paint shall be gray as shade 631 of IS: 5.
15.	Checking of control for its condition.	Control cables shall be replaced on age cum condition basis. Rubber gland should be replaced to prevent ingress of water.

3.3 TANKING OF TRANSFORMER

Finally put back the bell tank, assemble the bushings, check tightness of all internal connections, and provide new gaskets. The insulating oil has to be checked/tested as per IS: 1866-2000 and its replacement has to be done on its condition basis. Summarized guidelines of IS: 1866-2000 are given in a table at Annexure II. The filtration of the transformer oil is to be done by using oil filtration plant.

Check the alignment of core in the tank after tanking as under:

(a)Core/yoke frame are aligned with the tank bottom placing the transformer feet at correct location aligning them with the locating pin welded in the tank bottom.
(b)Core yoke is aligned /locked with the locking box provided at bell tank top through locating post welded in the yoke frame.

3.4 Drying-out/filtration of transformer

Vacuum drying of the transformer is to be done generally as per IS 1866: 2000 and by maintaining the pressure less than 0.10 torr and maximum temperature of 60^0C. During filtration/drying out process, the reading of temperatures and IR value shall be recorded every two hours form commencement till full operation is completed.

The filtration/ drying out shall be done as per para 20208/20210 of ACTM - Vol. II, Part I which is reproduced at Annexure-II for ready reference.

To ensure that the moisture has been removed from the transformer, the PI value after drying has to be measured and it should preferably be achieved equal to or more than 2. The following table is to be used as guideline reference for the PI value of the windings.

Item to be inspected/tested	Inspection/Testing	Action required / acceptance norms	
IR of winding and Polarization Index (PI) with 5kV megger for: HV-LV, HV-LV,E, LV-HV,E	Insulation resistance to be measured *for 10 sec, 60 sec and 600 sec. Calculate PI as R60/R10 and as R600/R60.*	Compare with values at the time of commissioning/ last recorded.	
		PI	Insulation condition.
		< 1.0	Dangerous
		1.0 – 1.1	Poor
		1.1 – 1.25	Questionable
		1.25 – 2.0	Satisfactory
		> 2.0	Good

3.5 PRECAUTIONS

Experience has shown that tools like spanners and foreign objects like washers, pieces of cloth, etc. are sometimes inadvertently left behind in the transformer which present hazard of short circuits. It is, therefore, important that the tools, etc. used during overhauling shall be listed out at the beginning and accounted for at the end of the work.

4.0 CHECKS / TESTS AFTER OVERHAULING

After completion of overhauling of transformer test/ checks shall be done:-

i) Voltage ratio test with Voltmeter, Ammeter and Lamp or with ratio meter.
ii) Winding resistance test with Whetstone Bridge or voltmeter, ammeter method.
iii) Magnetizing current test with voltmeter, ammeter and lamp.
iv) IR of windings and polarization Index with 5 kV Megger.
v) Tests on transformer oil for BDV, ppm, tan delta and acidity.
vi) Checking of protection equipment for their working i.e. buchholz, PRD, MOLG, WTI and OTI.

vii) All gasket joints for any leakage.
viii) Check relay and alarm contacts for their operation.
ix) Check control boxes, terminal boxes etc. for water tightness against ingress of moisture and if required replace gasket.
x) Check dial type OTI and WTI for freedom of pointer.
xi) Check the IR value and the secondary winding resistance of bushing CTs.
xii) Bushing: tan delta and capacitance test should be conducted to ensure its health and tallied with its prior test values. Max. allowable Tan Delta and capacitance is 0.007 and 110% of the factory set value respectively.
xiii) OCTC is to be checked for its proper /required operation such as
(a) Manual
(b) Local operation (electrical)
(c) Remote electrical operation
xiv) (a)Check oil level in transformer tank, conservator, condenser bushing, and OCTC etc.
(b)Check OTI and WTI pockets and breather oil cup and replenish the oil if required.
(c)Arcing horn gap as per drawing
xv) Check that all earthing connections of various parts/points are made properly as per diagram plate.
xvi) Check wherever provided, air delivery cooler fan are sufficient and working in right direction.
xvii) Ensure silica-gel in breather active and blue and oil is upto correct level in the cup.
xviii) Check the thermometer oil pockets on tank top and header etc. filled properly.
xix) Remove/clear all the tools and other associated equipments used in the POH from transformer.
xx) Lock the roller to prevent the movement on rail.
xxi) Release the trapped air through air release plugs and valves.

5.0 COMMISSIONING OF TRANSFORMER

The Commissioning of traction transformer after POH shall be done as per para20905/20906/20907 of ACTM - Vol. II, Part I which is reproduced at Annexure-II for ready reference.

6.0 Conclusion

Performance of transformer after POH shall be evaluated by comparing the result of insulation resistance & polarization index of windings and BDV, water content (ppm) ,tan delta, acidity & DGA of transformer oil. All these values shall be kept in records for monitoring the performance in service.

Each Railway shall be taking into consideration the resources available with them to carry out the POH & repairs of the transformer.

ANNEXURE-I

A) ITEMS REQUIRING REPLACEMENT WITHOUT FAIL DURING PERIODIC OVERHAUL OF TRACTION POWER TRANSFORMER.

1. Insulating oil

a) Insulating oil from OCTC.
b) Condenser bushing insulating oil.
c) Insulating oil from radiator.
d) Replenishing insulating oil from (i) OTI and WTI pocket (ii) Thermometers oil pockets (iii) Breather oil cup.

2. Gasket and Rubber items

a) Main gasket synthetic rubber cork gasket fitted between bell and bottom of the transformer tank
b) Inspection cover gasket
c) Gasket between tap changer flange and transformer tank
d) Gaskets for valve flanges
e) Gaskets for radiator valve flanges
f) Gaskets for turret and bushings flanges
g) Gasket between PRD and transformer tank cover
h) Gaskets between flanges of connecting pipe line
i) Gaskets between bushing porcelain and flange and porcelain and stem of the bushings etc.
j) Neoprene rubber gaskets used in breather between top lead and body.
k) Rubber sealing of Marshalling box and oil rubber rings oil gland and oil seals used at various locations including cable glands.

3. Precompressed board used to insulate bottom of tank with active parts.

4. Silica gel

ANNEXURE-I

B) ITEMS REQUIRING REPLACEMENT DURING POH ON CONDITION BASIS.

1.0 Insulation Material

SL. No.	Internal parts/Items	Condition
i	Permali wood packing in coil clamping and locking box welded to tank and core packing etc.	Deshaped due to pressure / vibration
ii	Coil clamping screws and plate Belleville washer, permali wood packing used in with hydraulic jacks for clamping coil at required pressure.	Replace the unit if not maintaining required pressure for coil clamping/ or replace Belleville washers with screws (only if deshaped/cracked)to achieve the purpose .
iii	Radial paper covered insulation over leads from windings to tap changer	Changed the lead or only paper insulation to solve the purpose.
iv	Radial paper covered insulation over leads to bushing with clamping arrangement permali wood / PCP board.	Changed the lead or only paper insulation to solve the purpose. Changed the clamping arrangement if not supporting properly being worn out.
v	Radial paper covered insulation between winding sections of both legs.	Changed lead/paper insulation only as per requirement.
vi	Fibre glass ferrule and insulating core/yoke bolts with permali washers and PCP board(used to insulate yoke with core stud)	Check dielectric strength of core bolt insulation with 3 kV for 1 minute and replace if damaged.

2. Items used in Winding

SL. No.	Items used in winding	Condition
i	Locking spacers	If lose and deshaped due to vibration
ii	Plain spacers	If lose and deshaped due to vibration
iii	Keyed blocks for tapping windings	If lose and deshaped due to vibration
iv	Keyed blocks for HV and LV winding	If lose and Deshaped due to vibration

v	Core packing of PCB /Perma wood	During removal/replacement of winding coils
vi	Top/bottom common washers of PCB	During removal/replacement of winding coils. If Deshaped /unserviceable
vii	Top /bottom clamping ring of PCB	During removal/replacement of winding coils. If Deshaped /unserviceable
viii	Windings: a)HV winding coil b)LV winding coil c)Tapping winding coil	Shall be replaced if open circuited /short circuited or burnt due to overloading or any reasons.
ix	All pre compressed board items to windings such as spacers,blocks packing ,clamping rings ,angle rings,angle caps and washers etc.	Shall be replaced along with associated winding coils if they are replaced due to various defects.

3. Other Items

SL. No.	Other items	**Condition**
i	a)Cable clamps /securing arrangement b)Cable glands c)Cable lugs	Damage/worn out/deshaped
ii	Nut bolts	Thread worn out
iii	LED/Bulbs	If not glowing /fused.
iv	Relays/switches	Erratic behavior
v	Push buttons	Not working
vi	Capillary tubes with bulbs	Not working
vii	Primary bushing terminal connector(Rigid)	Deshaped due to tightening in service
viii	Secondary bushing terminal connector (expansion type) or its part such as a)Spring washer b)Bimetallic sleeve c)AAC shunt	Deshaped due to tightening in service. Flattened Deshaped cut

ANNEXURE-I

4. Items /parts relating Tap changer(OCTC)

SL. No.	Parts	Condition
i	Bakelite phase board and selector ring	If cracked /damaged
ii	Brass slip rings	If worn out
iii	Brass fixed contacts	If worn out
iv	Electrolytic copper moving contacts	If worn out
v	Spring in moving contact holder for contact pressure	If softened/pressure disappeared
vi	Copper brush assembly	If worn out
vii	Bearing for selector shaft	If worn out
viii	Flexible braid of electrolytic copper to connect moving contact and copper brush	If strands damaged/cut
ix	Paper covered copper connection cable with socket (between fixed contact and terminal stud)	If insulation perished and copper strands damaged.
x	Epoxy moulded terminal ,bush and terminal board	If cracked
xi	Gears and bearing in driving mechanism	Teeth broken worn out noisy /sluggish operation.

ANNEXURE-II

Reference para of AC Traction Manual-Volume II (Part I)

Para 20206

Traction Transformers are usually provided with off-load tap changers (operated locally or by remote control) with taps from +10% to (-)15% in steps of 5%.To decide the correct tap setting a recording voltmeter should be connected at the traction sub-station to the secondary side of a potential transformer to ascertain the pattern of voltage variation throughout the 24 hours for at least 3 typical days. Based on the readings from the recording the tap position should be fixed so that the daily OHE voltage peaks at the traction sub-station lie just below 27.5 kV but does not touch 27.5 kV. This will ensure that the OHE voltage is well above the minimum of 19 kV at the farthest point on the system even when heavily loaded. Once a year a 24 hour record of voltages available on the two sides of every neutral section should be taken to make sure that the voltage does not fall below 19 kV at any time.

Since any change in the inter-connections of the grid system would have repercussions on the voltage at the traction sub-station, the CTFO(PSI) should keep in touch with the supply authorities in regard to system changes so that he may arrange to take another set of 24- hour voltage readings if any change has taken place and to change the tap setting if required.

Para 20208

The object of oil purification is to remove all contaminants such as water, carbon deposits, dirt, sludge, dissolved moisture and gases. The most important quality to be preserved is the di-electric strength, which is affected by the presence of moisture.
The insulating materials used in the winding are hygroscopic by nature and therefore moisture is absorbed through defective breathers, gaskets and addition of untreated oil. It is essential to remove these impurities by purifying the oil when the di-electric strength goes below the permissible limits.

Para 20210

Readings of temperature and insulation resistance should be recorded every two hours, from commencement until the full operation is completed. If the readings are plotted on a graph, the appearance will be as shown in ***Fig. 2.01*** *of ACTM.*

ANNEXURE-II

Reference para of AC Traction Manual-Volume II (Part I)

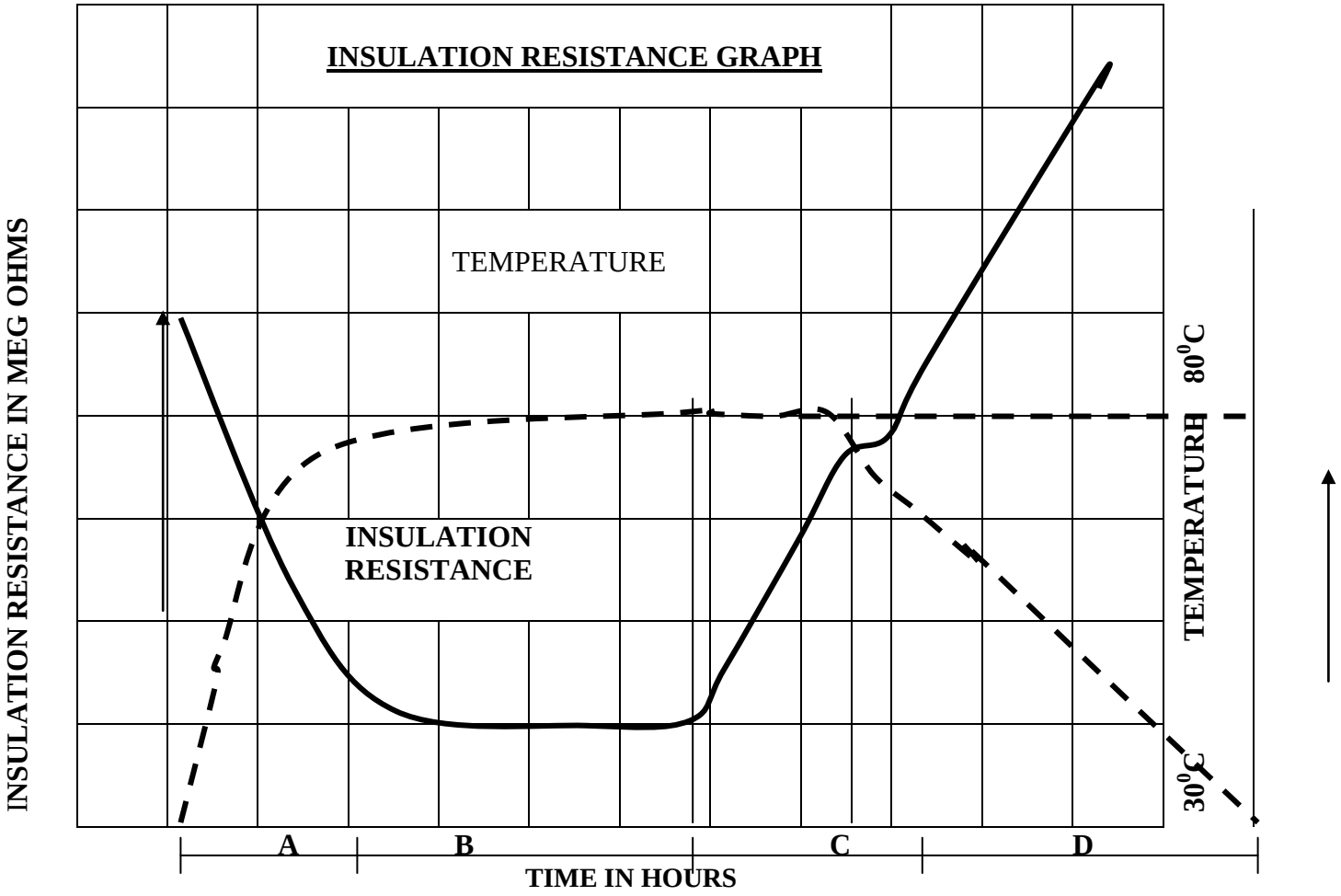

FIG. 2.01(PARA 20210)

It will be observed that there are four distinct stages:

A. *Initially the insulation resistance drops down to low value because of rise in temperature of the oil up to about 75 ^{0}C.* **(to be limited to 60 ^{0}C).**

B. *Insulation resistance will continue to remain at low level despite temperature being maintained at a high level until most of the moisture from the winding and oil has been driven out.*

C. *The insulation resistance will thereafter rise gradually and level of, indicating the all moisture has been driven out and the drying out operation has been completed. At this point oil circulation should be discontinued.*

D. *As the oil cools off, the insulation resistance will rise much above the levelling off point at the end of the stage(C). This is because the insulation resistance value doubles for a fall in temperature of about 10 ^{0} C to 15 ^{0}C.*

ANNEXURE-II

Reference para of AC Traction Manual-Volume II (Part I)

Para 20905

During the preparation for commissioning of transformers at traction substations in addition to manufacturer's instructions, the following steps shall be taken:

i) Drying out of transformer shall be undertaken as per the procedure laid down (Refer para 20208).

ii) Tap -changing mechanism shall be checked for being in perfect operating condition, both electrically and mechanically. Ratio test should also be done in this procedure (Refer para 20206).

iii) Transformer bushings should be paid special attention to ensure that the manufacturer's seal is intact and the bushings are in excellent condition. The insulation resistance of the bushing should be around 10,000 Meg Ohm. .

iv) All gaskets should be properly compressed and tight fitted. No leakage of oil should be visible from valves, pipe joints, gauze glass, radiators or any other parts of transformer. The welded joint should also be checked for oil seepage, if any.

v) For a substation with more than one transformer, they should preferably be identical. The polarity on both should be checked.

vi) The oil filled in transformer should be fully de-aerated to avoid false operation of Buchholz relay.

vii) The Buchholz relay should be erected as per instructions of the makers and tested for correct operation.

viii) All accessories like silica gel breather, vent pipe, explosion vent diaphragm, circulating oil pump and special cooling equipment, if any, should be checked.

ix) In addition, to Buchholz relay, (refer para 20214) other protective devices provided for the protection of the transformer (refer para 20212 , 20213) should be examined and checked carefully and tested after erection at site.

Para 20906

While working on traction transformers, the following special precautions should be taken by all the staff.:

1. *It is very important that one working on a transformer with any of its covers open should remove all loose articles from his clothing such as pens, pencils, watches, money, smoking articles, tools particularly if they are oily, as they are liable to slip and fall into the transformer in the course of work. The number of men working on top should be restricted to the minimum if tools have to be used they should be fastened by lengths of strings to the workers wrists or to the tank rim.*
2. *Moisture lowers the dielectric strength of the oil, and hence every possible precaution should be taken to prevent its entry. Sweat on hands and face should be wiped off frequently by a dry cloth and tools should be kept clean*

ANNEXURE-II

Reference para of AC Traction Manual-Volume II (Part I)

and dry, especially when coming in contact with oil. Another source of entry of moisture into the tank is by condensation. If a transformer is at a lower temperature than its surroundings, condensate will form on the exposed surfaces. Transformer should, therefore, be at or above the ambient temperature before being opened for work at any time.

If any cleaning or wiping is necessary, this should be done with clean dry oil using soft, non- fluffy cloth, and never by using cotton waste.

Para 20907

i) Insulation resistance readings should be recorded with a 2500 V or 5000 V megger. The following are the minimum permitted values at an ambient temperature of 30 ^{0}C . Temperature has a material influence on insulation resistance, and therefore the tests should not be conducted when oil is hot.

2000 Meg Ohm between EHV winding and earth.
400 Meg Ohm between 25 kV winding and earth.
2500 Meg Ohm between EHV and 25 kV windings.

ii) Test on insulation: The test consists of applying dc high voltage (2500 V or 5000 V), with the help of a megger, continuously between winding and earth, and noting the insulation resistance at the end of 10 seconds, 60 sec. and 600 sec. To maintain constant voltage, a motor- driven megger is preferable. The polarization ratios R60/R10 and R600/R60 should not be less than 1.4 and 1.2 respectively. (R10, R60, R600 are the insulation Resistance values after 10 sec. 60 sec. and 600 sec respectively).

iii) Phasing out Test: This is comparatively easy, as single phase transformers alone are provided at traction sub-stations; if both the transformers installed at a substation are of identical manufacture the terminal connections will be identical. Nevertheless, the correctness of polarity should be checked by applying 400 V across the primaries in an identical manner and measuring the relative voltage between the two secondaries of transformers after connecting one terminal of one secondary with the corresponding terminal of the other.

iv) *Oil Test: The tests on transformer oil should be done in accordance with IS- 1866 for oil in use (See Annexure 2.03B Chapter II).*

Para 20212

Alarm and trip contacts are provided to operate should the temperature of transformer windings or transformer oil exceed pre-set limits. If alarm or the trip contacts have operated, both of which are indicated at the RCC, CTFO should personally inspect the

installation. If the dial settings are correct, the reason for excessive temperature rise should be investigated. Normally instantaneous overloads of over 150% are cleared by thermal protection. It is advisable to connect a recording ammeter and get a 24 hour chart showing the current loading of the transformer in services. The shape of the load curve would give valuable clues as to corrective action to be taken.

If the alarm and trip circuits operate frequently during peak periods, attempt should be made with Operating Department to space out the trains more uniformly throughout the day so as to reduce the peak load. If, on the other hand, it is a suburban section and the peak load cannot obviously be brought down, the second standby transformer may have to be pressed into service for the duration of peak load. Such parallel operation of traction transformer may some times may also incidentally result in reduction of the total losses thereby effecting economy. Secondly, it will also result in higher OHE voltage, since traction transformer impedance is now halved, as the transformers are identical

If a substation is persistently overloaded and an adjacent sub-station is appreciably under loaded, the possibility of shifting the neutral section may be considered.

Para 20213

Apart from operation on account of internal faults in the transformer, the differential relay could also operate either because of current in-rush on account of magnetization of the core at the time of switching on or because of spill current caused by lack of perfect balance between secondaries of EHV and 25 kV current transformers. The causes for such mal- operation may be defective harmonic restraint filters or wrong CT ratios and should be eliminated.

Para 20214

The Buchholz relay assembly is provided on transformers to detect evolution of gas caused due to internal faults. After first commissioning, the upper assembly of the relay may sometimes be found to operate causing the relay to trip. Analysis of the composition of gas collected will indicate the nature of fault. If it is mere air bubbles the transformer is sound. Fir details of tests manufacturers write up may be referred to. It is always a wise policy to get the die- electric strength of the oil tested, measure the insulation resistance and carry out ratio test.

ANNEXURE-II

Reference para of AC Traction Manual-Volume II (Part I)

Annexure 2.03B
(Para 20207) of ACTM Vol.II Part-I

(The values from latest IS: 1866-2000 has been taken while ACTM table is having the values from IS: 1866-1983)

APPLICATION AND INTERPRETATION OF TESTS ON TRANSFORMER OIL IN SERVICER

SL. No.	*Tests*	*Value as per IS: 1866-2000 permissible limits*	*To be re-conditioned*	*To be replaced.*
1.	*2.*	*3.*	*4.*	*5.*
1.	*Electric strength (Breakdown voltage)* *Below 72.5 kV* *72.5 kV and less than 145 kV* *145 kV and above*	*Min.* *30 kV* *40 kV* *50 kV*	*Less than the value specifified in column 3*	--
2.	*Specific resistance (Resistivity) Ohm-cm at 90 ^{0}C*	*Above 1x 10^{12}*	*Between 0.1 x 10^{12} to 1 x 10 ^{12}*	*Below 0.1 x 10 ^{12}*
3.	*Water content* *below 145 kV* *Above 145 kV*	*Max.* *40 ppm* *20 ppm*	*Greater than the value specified in column 3*	--
4.	*Dielectric dissipation factor, Tan delta at 90 ^{0}C*	*0.2 or less*	--	*Above 0.2*
5.	*Neutralisation value mg KOH/ g of oil.*	*0.3 or less*	--	*Above 0.3*
6.	*Interfacial tension N/ m*	*0.015 or more*	--	*Below 0.015*
7.	*Flash point in ^{0}C*	*140 or more*	*125 and above but below 140*	*Below 125*
8.	*Sludge*	*Non- detectable, Results below 0.02% by mass may be neglected*	*Sediment*	*Perceptible sludge*
9.	*Dissolved Gas Analysis (DGA)*	*Refer Annexure 2.04 of ACTM Vol.II Part-I*		