(FOR INSTALLATION, COMMISSIONING & MAINTENANCE OF TRANSFORMER)

SERVICE MANUAL

TMC TRANSFORMERS INDIA PVT. LTD.

TMC TRANSFORMERS INDIA PRIVATE LIMITED

TMC TRANSFORMERS INDIA (PRIVATE) LIMITED is incorporated in the year 2009. TMC India has become group company of United Insulation Industries & started their state of art manufacturing facility near Vadodara.

TMC India management is well I experienced in manufacturing of transformers since 1997. TMC India follows a technically proven and time-tested design and manufacturing technology. TMC India is an alliance partner of Transformer Manufacturing Company Pty Ltd, Australia.
TMC-Transformers Manufacturing Company Pty Ltd, Australia -the original TMC-was established in Melbourne, Australia in 1936.

TMC has been manufacturing transformers for more than 80 years and cast resin transformers for more than 30 years. TMC plants in Australia and Spain has produced more than 15,000
transformers which have been installed all over globe.

TMC India is located on Vadodara- Halol highway. Factory is situated in 35,000 sq.mtr area in which 8,000 sq.mtr is covered area. TMC Factory is equipped with modern machinery to produce quality transformers. TMC India Factory can produce 1000 MVA equivalent dry type transformers and 2000 MVA equivalent oil filled transformers per year.

TMC uses most advanced production technology and machinery to produce high voltage and low voltage windings. Core laminations are procured from reputed/approved manufacturers and core assemblies are tested for core losses. Assembly of Core and windings is done by well experienced work force. Quality parameters are verified at every stage of manufacturing.

All transformers are tested at NABL accredited in-house test lab which can test transformers as per IS 2026, IS 11171& IEC 60076 standards. Partial discharge test as per IEC 60076-11 can be performed at in-house test facility.

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SECTION – 1 ***PAGE NO.***

➢ GENERAL INTRODUCTION:

Transformer is a static equipment, which converts electrical energy from one voltage to another. As the system voltage goes up, the techniques to be used for the Design, Construction, Installation, Operation and Maintenance also become more and more critical.

If proper care is exercised in the installation, operation, maintenance and condition monitoring of the transformer, it can give the user trouble free service throughout the expected life of equipment which is of the order of 20~25 years. Hence, it is very essential that the personnel associated with the installation, operation or maintenance of the transformer are thorough with the instructions provided by the manufacturer.

This Manual contains general descriptions about Transformers & specific details about the particular contract against which the Transformer is supplied. Also, it contains instructions regarding the safety aspects, erection, commissioning, operation, maintenance & trouble shooting of large capacity Power Transformers.

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1) TRANSPORT & PACKING & DESPATCH

a) GENERAL

Depending on the restriction imposed by the weight and transport dimensions, the transformer will be despatched either in oil filled or nitrogen gas filled condition.

In case of transformer despatched without oil, the transformer will be pressurised with dry nitrogen gas to minimise the likelihood of condensation or moisture entering the tank.

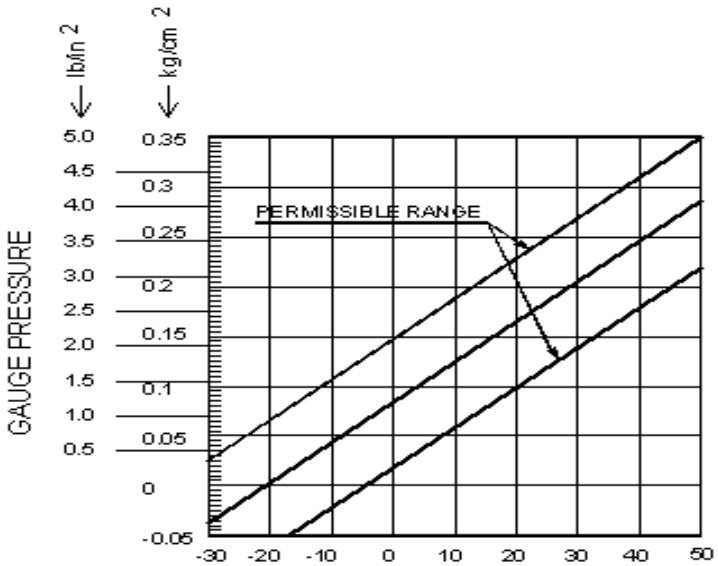


FIG. - 2.1

Transformers are supplied, fitted with nitrogen gas cylinder to maintain positive pressure during transportation and storage before erection.

While transformers are in transit, gas pressure must be checked on daily basis and any loss of pressure must be made up by feeding gas from the cylinder. For allowable range of pressure at various ambient temperatures, please refer to Fig. 2.1.

Accessories and cooler are despatched separately. All oil pipes and chambers are despatched in sealed condition to avoid entry of water during transportation and storage.

b) PACKING

When any internal part like tap changer, CT's etc. are removed from the main body for transportation, they shall be despatched in tanks filled with oil or dry nitrogen gas or suitable measures are taken so that they do not absorb moisture.

All fragile parts such as temperature indicators, oil level gauges etc. shall be carefully packed to avoid breakage in transit.

Air cell type conservator shall be despatched with air cell mounted inside the conservator and inflated with air at a slightly positive pressure so that it remains fully tight inside the

conservator. This is to avoid relative movement of air cell inside the conservator during transit and to avoid damages to air cell during handling.

All blanking plates, valves guards etc., which are used exclusively for transportation are painted with a different colour shade than the transformer (normally post office red) and shall be preserved for future use.

c) LIFTING

Transformers should be lifted only by using the lifting bollards provided on the main body for the purpose. All the lifting bollards should be used simultaneously. Care should be taken to use the correct size of sling for lifting and the lifting angle should not exceed 60^0 from horizontal.

Safe loads of wire ropes and the multiplying factor to be used corresponding to the lifting angles are shown in Fig. 2.2

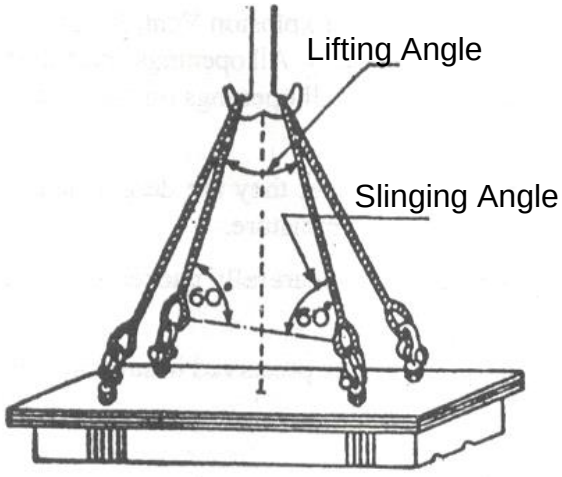


Fig. 2.2

Correct method of slinging

MULTIPLYING FACTOR FOR DIFFERENT LIFTING ANGLES	
Lifting Angle	**Multiplying Factor**
0	1.000
20	1.015
40	1.065
60	1.155

SAFE LOAD OF WIRE ROPES	
Dia. of Wire Rope mm	**Safe Load kg.**
6	600
12	1,300
16	2,300
20	3,500
24	5,000
28	7,000
32	9,000
36	11,000
40	14,000
44	17,000
56	24,500
64	33,500
70	40,000

d) JACKING

For the purpose of jacking, only the jacking pads provided on the tank are to be used. Capacity of Jacks should be at least 1.5 times the weight of transformer. Put sufficient wooden/steel packing below the jack to support the weight. Do not lift more than 30 mm at a time. Use all jacks simultaneously. Jacks should not be left in the loaded position for long time. Transformer should be handled only in the normal upright position.

Rollers should be used for shifting the transformer from one place to other. Roller axles or radiators should not be slinged for the purpose of towing. Pulling holes provided on the tank for this purpose should only be used.

Transformers of higher ratings are provided with four jacking pads. Each jacking pad is designed to take approximately 33.33% of the total load. Under no circumstances, jacking should be used anywhere else other than these specially provided pads.

e) STORAGE

On receipt of the Transformer at site, it is desirable to install and commission the transformers with minimum delay. In case, this is not possible, the silica-gel breather should be fitted. The breather incorporates an oil sealing device which must be filled with oil to the marked level to be effective. A periodic watch should be kept on the silica-gel breather to ensure that the gel is blue. The gel should be replaced or dehydrated immediately on its tunings Pink/Green.

It is advisable to check the condition of silica gel during storage at least once a week and Break down Voltage (BDV) of oil at least once in a month and should be maintained at a level of 50 KV. It is desirable to keep the transformer energised even at a low voltage so that the oil temperature is about 10° to 15° C higher than the surrounding ambient temperature.

Accessories like, bushings, buchholz relay, dial type temperature indicator, terminal box, radiators, all pipe work, should be stored indoors till such time they are not required. It they are not stored properly, they are likely to be damaged. The conservator pipe work and radiators are despatched with blanking plates and these are to be stored with their blanking plates, in position.

It these are stored for a longer period like six months or so, it advisable to flush them with clean transformer oil before use.

f) SHIPMENT OF OIL

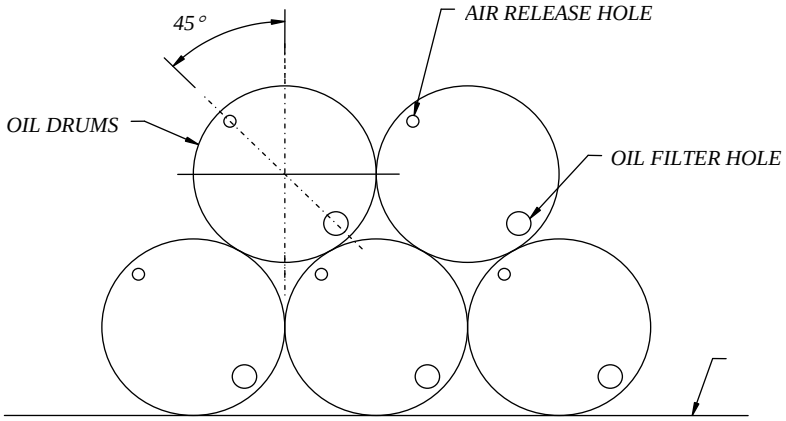
Transformer oil is despatched to site in sealed steel drums or tankers. When oil is filled in

drums, there should be sufficient air space to allow for expansion and contraction of oil due to variations in temperature. Drums should be stacked only in horizontal position with the oil.This will avoid collection of water on top of the drum, which may be sucked in by the vacuum created inside the drum due to the expansion and contraction of oil owing to changes in ambient temperature.Due to any reason, if the drums are kept in vertical position, drums should be covered with polythene or tarpaulin sheet to avoid risk of water getting collected on top and eventually leaking into the drums.

Filter holes and air release holes shall be in one horizontal line. This will avoid breathing in of moist air. If there is any leakage of oil it can easily be identified.

When oil is transported in tankers, there should be storage tanks of sufficient capacity available at site. Such tanks should be fitted with dehydrating breathers.

STORAGE OF OIL DRUMS



g) RECEIVING MAIN UNIT AND ACCESSORIES

When a transformer arrives at site a careful external inspection must be made of the unit, its cooling system and all sealed components, referring to the general arrangement drawing and the shipping list.

Inspect all packing cases and loose components for damage or missing items.

Check whether the transformer has arrived at site with a positive gas pressure in case of despatch without oil. In case of despatch of main body in oil filled condition, the oil level should be checked. One transport oil level gauge is welded near the top of the tank for indicating the level of oil in the tank.

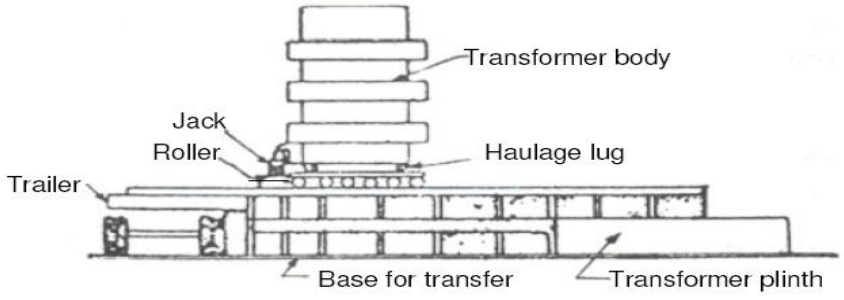
Should the transformer arrive at site without pressure (owing to gas leakage) it must be assumed that moisture has entered the tank and that the moisture will have to be driven out. In such cases the manufacturer's advice must be sought.

Confirm that case numbers match with the packing list. Check their contents tally with the packing list if the packing case is damaged.

IMPORTANT: *If any scratches or damage to the paint is noticed on receipt of Main body or Accessories, touchup painting should be done immediately over the damaged area. For procedures of touchup painting, refer to " Clause 4.22: Touchup Painting at site".*

h) UNLOADING OF MAIN UNIT

In cases where the substations are having adequate crane facility; the transformer is unloaded by crane. Alternatively, mobile cranes are used. Where no crane facility is available a trench is due to a depth equal to height of the trailer platform and the transformer is slide to position. If this also is not possible the transformer is unloaded into a sleeper platform and gradually lowered to plinth level. The sleeper platform level is to be at a slightly higher level to allow for the increase in height of the trailer while the load is released due to the springs getting relaxed. Winches are to be used for putting the transformer into position.



Lift the main body of the transformer with a mobile crane and wire ropes. The crane capacity must be at least 10% higher than the weight of consignment. Lifting angle of ropes should be limited to 30 deg. to vertical.

Unloading must be done with maximum care, avoiding any jerking movements or dropping.

Use only the lifting bollards/hooks for slinging while lifting.

For lifting with hydraulic jacks, the transformers are provided with jacking pads dimensioned for lifting the complete transformer filled with oil.

If the foundation of the transformer is not ready and if the transformers are to be unloaded temporarily, it should be done on levelled hard surface.

Under base of the transformer should not rest on the ground as it will lead to rusting of the transformer.

i) PLACING IN POSITION

If foundation is ready and if rail link between unloading point/storage place is available, then the main body of the transformer must be moved on its own rollers to the foundation where the transformer is to be erected finally.

If the transformer is not provided with rollers and if it is to be erected on its skid base, the transformer must be slid to its final position using greased steel plates to protect the plinth surface and make movement easier. The plates should form a continuous surface and it must clear the final jacking areas.

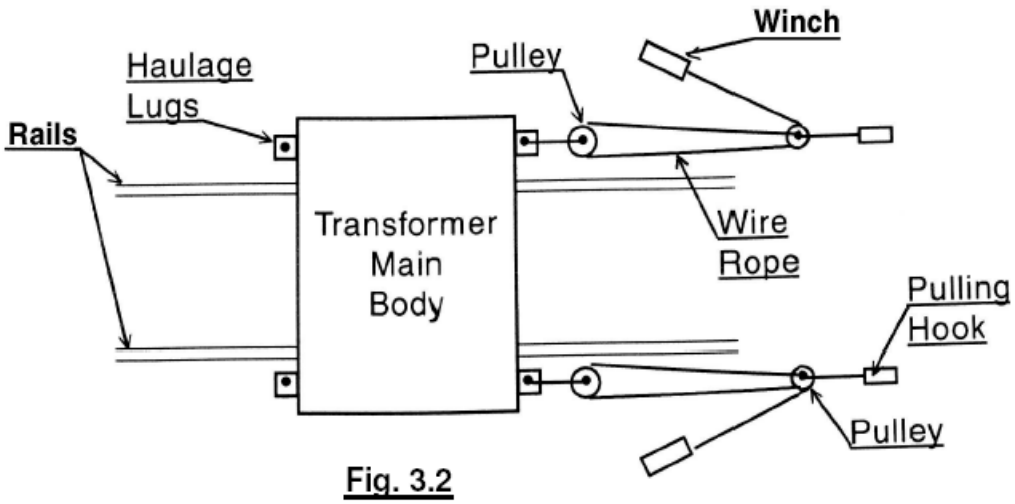


Fig. 3.2

The transformer must be pulled by using wire ropes and winches as shown in Fig.3.2. Use only the specified haulage lugs for pulling. Pulling capacity of winches should be more than (Main body weight x 0.15/4) tons. Pulleys should have a capacity of (Main body weight x 0.15/2) tons. When jacking, position the jacks under specified jacking pads only. When jacking, ensure that all four jacks are operated simultaneously.

Before lowering, clean all grease dirt etc. from the under base of the transformer.

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2) INSTALLATION

2) INSTALLATION

a) LOCATION

The transformer should be kept in a well ventilated place, free from excessive dust, corrosive fumes etc. Adequate ventilation is necessary for tank and radiators so that they can dissipate heat. There should be clear space of about 1.25 m on all sides of the transformers if it is enclosed in a room.

b) FOUNDATION

Foundation should be firm, horizontal and dry. where rollers are fitted, suitable rails should be provided.

c) PROVISIONS FOR OIL DRAINING:

Necessary provisions for oil draining; in the event of a fire, should be made by way of Oil Soak Pits. Fire separation walls should also be provided when necessary.

d) ASSEMBLY OF DISMANTLED COMPONENTS:

Various components dismantled for transportation should be duly assembled.

- **MAIN TANK**

Keep the main tank in its permanent position of operation. Lock the rollers to prevent any accidental movement on rails. Draw an oil sample from the bottom of the tank and test it for Break-down-Voltage (BDV).

- **BUSHINGS:**

Clean the bushings and check that there are no hair-cracks or other damages. Test IR value of each bushing with a 500V Megger. It should be 100 M ohms or greater. Note details of Bushings in the "Commissioning Report." Mount all the bushings, Ensure that the test cap is fully tightened, thus positively grounding the same. Adjust the Arcing Horn Gaps in accordance with the Insulation Co-ordination.

- **CONSERVATOR & MOG:**

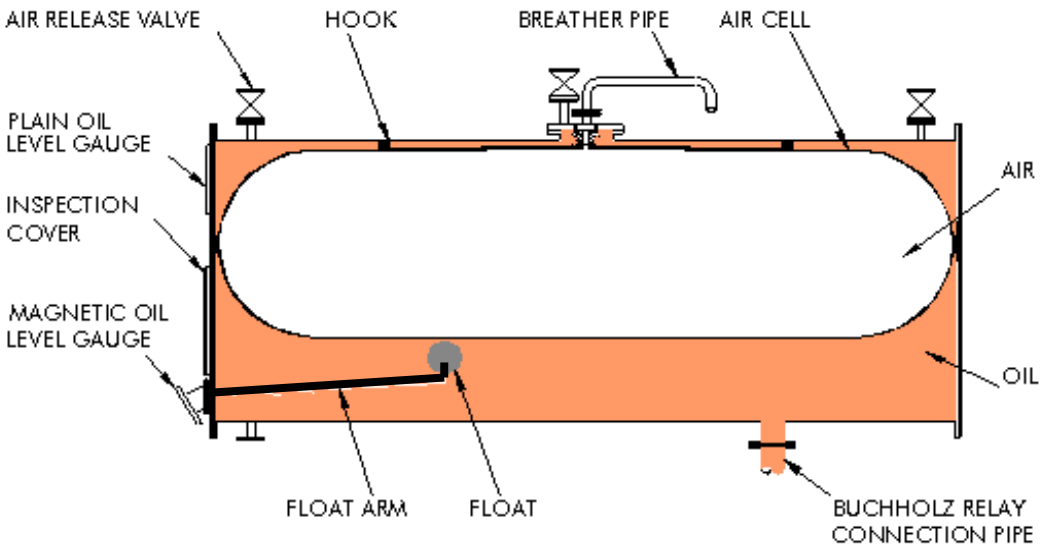
If the M.O.G. is provided with a locking lever, it should be removed. Mount the conservator. When there is an OLTC, its conservator is sometimes provided separately or by making a partitioned compartment in the main conservator. OLTC conservator, if separate, should also be mounted. **Mount the conservator** as shown in G.A. Drawing.Very often the small conservator for on

load tap changer is attached to the main conservator.

Usually the main conservator is provided with Magnetic Oil level Gauge having low oil level alarm contacts and OLTC conservator is provided with oil sight window.Magnetic oil level gauge shall be mounted after attaching the float to the gauge. Check and confirm free movement of float arm and proper locking of float to the float arm.Mount all valves as shown in GA drawing on the conservator.

Mount the connecting pipe with Buchholz relay from the main tank to the conservator. Ensure direction of Buchholz Relay by the direction of arrow on Buchholz Relay towards conservator. Mount breather connecting pipes and silica gel breathers for the main tank and OLTC conservators.

METHOD OF MOUNTING FLEXI SEPARATOR (AIR CELL) INSIDE THE CONSERVATOR



PROCEDURE - I (OIL FILLING WITHOUT VACUUM)

- Set up the air cell in side the conservator. Care should be taken to see that the hooks on air cell are properly engaged in the brackets provided in side the conservator.
- Inflate the air cell at a pressure as shown in the instruction plate (DO NOT APPLY EXCESS PRESSURE AS IT MAY DAMAGE THE AIR CELL) through the breather connection pipe. Follow the instructions given in the Instruction Plate fixed on the transformer.

- Ensure that there is no leakage.
- The conservator with Air Cell is pressure tested and despatched from the factory at a slightly positive pressure. Confirm that there is no oil leakage.
- Fix three numbers air release valves on the conservator.
- Keep air release valves open. Fix air filling adapter on breather pipe and inflate the air cell at an air pressure indicated on the INSTRUCTION PLATE affixed on the transformer and hold air pressure.
- Open the air release valves and start oil filling from the bottom filter valve of the transformer.
- Observe the air release valves and as soon as oil starts overflowing, close the air release valves one by one. Stop oil filling when all air release valves are closed.
- Remove the air filling adapter.
- Continue oil filling and observe the Magnetic Oil Level Gauge (MOLG)
- Stop the filling when the needle of MOLG shows the level corresponding to the ambient temperature at the time of filling.
- Fix silica gel breather.

CAUTION: *Do not open any of the air release valves after completion of oil filling. If air release valve is opened, air will enter and oil level will drop.*

The plain oil level gauge on the end cover of the conservator should indicate f*ull oil level always. If air enters the conservator, it can be seen by a fall in the oil level in plain oil level gauge.*

The plain oil level gauge should be monitored on regular basis.

FILLING PROCEDURE UNDER VACUUM IN CONSERVATOR

The conservator, with its separator, being set up and plugged in above the transformer, is connected to its oil filling reserve by a pipe in its lower part.

Proceed as follows:

→ Create a vacuum in separator.

→ With the same source of vacuum, create a vacuum in the conservator.

→ Open the oil filling valve of the transformer. Because of the vacuum in the conservator, the oil level rises automatically.

→ Stop the oil filling once the required volume in the conservator is attained.

→ While maintaining the conservator under vacuum, allow Dry Air or Nitrogen gas to enter into the internal part of the separator. Then, the separator inflates by itself, and takes all the free space due to the fact that the conservator was not completely full. In particular, during the operation, the oil is going to rise to the top of the conservator.

→ Inflate the separator at a maximum as shown in the INSTRUCTION PLATE.

→ Check on the vent-holes, and confirm that there is no more air in the conservator or, if necessary, adjust the level.

- **BUCHHOLZ RELAY:**

Buchholz Relay floats are tied to prevent transit damage. They should be released. Also If 'Test' lever is provided, it should be in the working position.

- **BREATHERS:**

"If OLTC is provided, it may have its own separate breather."Check that the colour of Silica Gel in main breather is Blue. Remove the rubber cap closing the breather pipe and it the breather. Fill oil in the oil cup and remove the seal which closes the breather opening. Similarly mount the OLTC breather.

- **RADIATORS:**

i) Radiators are to be assembled only one at a time. Oil required to fill in the radiators is sent separately in drums. Test oil sample from each drum for BDV. Ensure it is more than minimum specified in I.S. 1866 for new Transformer.

ii) Fill the conservator full using an oil filter machine, if available.

iii) Clean one radiator externally. Remove blanking plates and clean the gaskets and radiator flanges. If gaskets are damaged, use spare gaskets.

iv) If blanking plates are not in position and it is suspected that foreign material might have entered the radiators, clean them internally by flushing fresh and clean transformer oil.

v) Oil might seep through the tank side radiator valves and be retained by the blanking plates. This oil should be collected in a clean container at the time of removing top and bottom blanking plates.

vi) Bring the radiator flanges close to the flanges on the tank. Ensure that tank gasket is in position. Fit by means of bolts, nuts, spring washers etc.

vii) Open the bottom radiator valve using the operating handle. Gradually unscrew the air release plug on the top of the radiator, until air starts escaping. Air release plug should not be removed from the engaging threads as it would be difficult to control oil coming out of it. When oil comes out steadily from the air release plug and no more air comes through, close the air release plug. Open the top radiator valve. Oil level in the conservator would now have fallen. Check that there is no oil leakage from the radiator itself and the gasket joints. Restore the oil level and assemble the next radiator in the same manner.

- **MARSHALLING BOX:**

i) Marshalling box should be fitted in Position. Pockets of O.T.I. & W.T.I., should be filled with transformer oil. Bulbs of O.T.I. & W.T.I. should be fitted in position in their respective pockets.

ii) Set the 'Alarm' & Tip' contacts of O.T.I. & W.T.I., at required values. O.T.I, setting of A=85°C & T=95°C W.T.I., setting of A=95°C & T=105°C are considered good. They can be worked out to suit local conditions.

- **CABLE BOX**

When Cable Boxes are provided they should be mounted and cable terminations done. Oil filled cable-boxes should be duly filled with oil. In case of "Bus-Duct" connections, transformer is provided with a flange to receive the bus-duct. Due to connection and fitting should be done to over-head line by a terminal connector.

e) AIR RELEASE:

Release air by slowly unscrewing Air Release Plugs provided at Bushings, Bushing Pockets, Buchholz

Relay, Main Tank Cover, Oil Surge Relay etc. From plain porcelain bushing of 11, 22 8t 33 KV, air can be released by loosening the nut pressing the rubber gasket and pressing the metal part down.

f) OIL SAMPLING AND FILTERING

Oil should not be filled in the transformer directly from the drums or transport container as there is a chance of precipitated water or sediments may also be pumped into the transformer along with the oil.

Oil from the drums or transport container should be filled into the oil storage tank and oil parameters should be tested before it is filled into the transformer.

If oil is received in drums, samples should be taken for testing from as many drums.

Table -1

Selection of Samples from drums

No. of Drums in a Batch	No. of Drums from which Samples to be taken
2 to 5	2
6 to 20	3
21 to 50	4
61 to 100	7
101 to 200	10
201 to 400	15
401 and more	20

Samples should be collected from the bottom of the drums for testing.

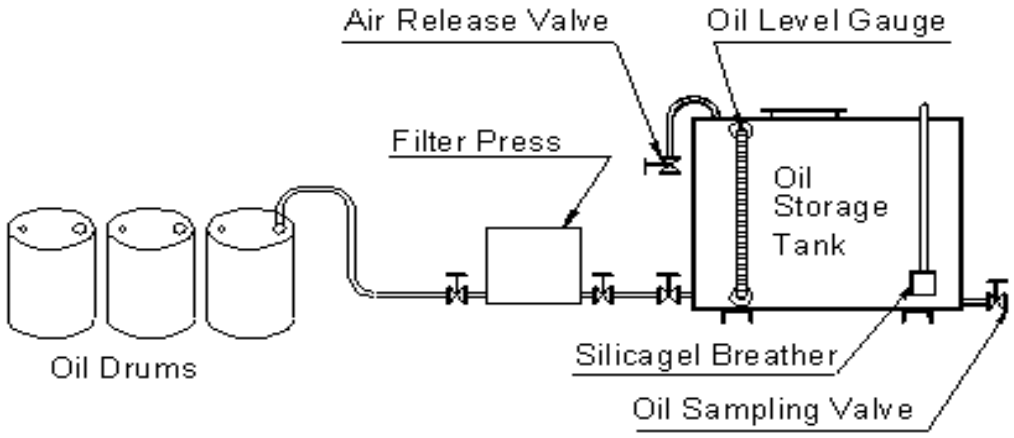
If oil is received in containers, oil sample shall be collected through the sampling valve at the tank outlet or by means of thief dipper as suggested for sampling of oil from drums. The container should be allowed to stand for atleast one hour before drawing the sample.

Conduct the following tests for ascertaining the quality of oil.

- Breakdown Voltage test
- Moisture content test
- Tan delta

- Resistivity

If oil does not meet the specified criteria, oil should be filtered and stored in the oil storage tank before filling in to the transformer.While pumping oil from the barrels, the barrels may be tilted



suitably to ensure that complete oil is taken out from each barrel.

g) PRECAUTION TO MAINTAIN QUALITY

- As a precautionary measure to restrict absorption of moisture, the transformer should not be exposed to atmosphere for more than 8 hours continuously and erection work should be scheduled accordingly.
- For high voltage jobs of 400 kV and above, dry air having dew point below -400C should be purged inside the tank during internal assembling work.
- Transformer oil should be tested for B.D.V. before filling and it should be more than 55kV at 2.5 mm gap.
- Extreme care shall be taken against any foreign objects falling inside the transformer tank during inside working.
- Keep only one man hole open at a time and close it as soon as possible. Avoid inside working on rainy days.
- Earthwork near the transformer should be avoided when internal assembly is in progress to avoid ingress of dust.

- Any tools taken inside should be tied by string or cotton tape to the person who is using the same. No. of tools shall be counted and recorded before and after each days work in order to ensure that no tools are left inside.
- Gaskets used are of synthetic rubber bonded cork material. These are to be compressed to 50 ~ 60% of its original thickness. Over tightening and under tightening of gaskets should be avoided as these may cause oil leakage and shortening of gasket life.

h) ERECTION OF COOLER BANK

- Generally for oil forced cooled transformers radiators will be mounted in a separate cooler bank.
- Cooler headers supporting 'A' frame are mounted on separate foundations. Refer "FOUNDATION DRAWING" for details.
- Since cooler headers are provided with butter fly type shut off valve, oil from main body need not be drained for assembling cooler.
- Cooler Assembly should be carried out referring to "GENERAL ARRANGEMENT" and "PART MARKING DRAWING" of the transformer.
- Check and ensure that level of all the foundations for cooler support are in same level as that of the top surface of rails. Level difference should be compensated by putting shims if the level is lower and chipping the concrete foundation if the level is higher.
- Fix cooler header mounting frames as per dimensions shown in General arrangement and Foundation Plan drawing.
- Mount cooler headers loosely. Final tightening to be done only after proper alignment.
- Top and bottom butterfly valves of all radiators should be in the vertical line. This should be confirmed by a plumb.
- Tighten the cooler frame foundation bolt, and clamping bolts of cooler headers and pipe connections.
- While mounting the oil pump and oil flow indicators, care should be taken to ensure the arrows indicating the oil flow direction are towards the transformer tank.
- While mounting radiators care should be taken to ensure that the weight is balanced.

- Ensure that a fresh gasket is used while mounting the radiators.
- In case of separately mounted coolers, the oil pipes are provided with expansion joints. Tack welded bars on expansion joints should be removed.
- Fix the fan mounting frames and fans as indicated in the general arrangement drawing.
- Fan & mounting frame shall be connected to the earth grid.

i) PRESSURE RELIEF DEVICE

→ Mount PRD as per manufacturers leaflet and also the G.A. drawing of Transformer.

→ Check operation of alarm/trip contacts.

SECTION – 3 ***PAGE NO.***

3) FITTINGS & ACCESSORIES

3) FITTINGS & ACCESSORIES:

a) RATING & TERMINAL MARKING PLATE: (R & D Plate)

The transformer is supplied with rating and terminal marking plate made out of noncorrosive metal. The plate contains information concerning the rating, voltage ratio, weights, oil quantity, vector group etc. The plate also includes unit Sr. No. and year of manufacturing.

b) TAP CHANGING ARRANGEMENT:

i) Off-Circuit Switch

The transformer is normally fitted with an off-circuit tap changing switch to obtain required voltage ratio. It can be hand-operated by a switch handle mounted either on tank cover or on the tank side. The locking device is fitted to the handle to lock in any tap position. The switch mechanism is such that it can be locked only when it is located in its proper position and not in any intermediate position.

THE TRANSFORMERS MUST BE ISOLATED FROM ALL THE LIVE LINES, BEFORE OPERATING THE SWITCH.

Operating the switch when transformer is energised, will damage the switch contacts due to severe arcing between the contacts and may damage transformer winding. When the switch handle is provided on the side wall, it is necessary that Switch handle assembly is dismantled before untanking.

ii) Off-Circuit Ratio Changing links:

Sometimes links are provided inside the transformers tank to obtain required voltage ratio. Links are required to be loosened and fixed in new required position as given in R & D Plate. Links are accessible from the inspection cover.

iii) On-Load Tap Changer:

The on-load tap changer is an optional fitting. The on-load tap changers are provided with local manual control, local electrical control and remote electrical control. The automatic voltage regulation can also be provided as an optional fitting. The tappings are located on high voltage winding.

c) EARTHING TERMINALS:

The core laminations assembly is connected to core clamping fame which is in turn connected to the tank. Two earthing terminals are provided on the transformer tank. The earthing

terminals should be connected to the earthing.

d) LIFTING LUGS:

Two/Four lifting lugs of adequate capacity are provided on tank sides/top cover to lift fully assembled transformer filled with oil. All lugs are designed for simultaneous use and must be used accordingly. Two/Four lifting lugs are all heavy fittings are also provided with individuals lifting lugs.

e) VALVES:

Every transformer is provided with drain cum filter valve at bottom of the tank, and filter valve at top of the tank. Valves are fitted with plugs/blanking plates to stop oil coming out.

Mainly two types of valves are provided.

i) Wheel Valves.

ii) Butterfly Valves.

The Wheel Valves are used either with female screw threads or with flanges. These are of gun-metal/cast iron type.

Generally, one isolating valve also known as shut off valve is provided for transformer up to 2000 KVA between conservator and buchholz relay. The Butterfly type cast-steel valves with the machined flanges are used at points of connection between tank and detachable radiators.

f) BUSHINGS:

Oil Communicating Type:

Transformers windings are connected to the external circuit through terminal bushings. The bushings are installed on the cover or, on side walls of the transformer tank. The lower ends of the bushing protrudes into the tank and at both their ends are provided with suitable fasteners to connect the line leads inside the transformers an external conductors outside it.

The shape and size of the bushings depend on the voltage class, type of current. Bushings of 1000 Volts are of two piece construction without arcing horns, whereas all other bushings are of single piece porcelain type. Assembly and dismantling of single piece type bushing is possible without disturbing the active part. For bushings of two piece constructions, tank cover is required to be removed for necessary access to the inner (lower) end of the bushings. These bushings are not detached at the time of transportation.

Condenser Bushings:

Generally, Condenser Bushings are used for 72.5 KV and above. These bushings contain their own oil and are sealed to retain the same. Whenever these bushings are mounted on bushing pockets or raised truncated portions, air vent pipes are provided for carrying away air or gases from these pockets to Buchholz relay during service.

These bushings are detached from the transformers and despatched separately, They are packed as per manufacturers' instructions. The draw through type lead is coiled and kept temporarily below the bushing blanking plate. The equipment required for mounting the bushings are (i) rope slings (ii) flexible steel wire approx. 2mm in dia., of suitable length.

Typing procedure for mounting is as follows:

(i) Open the bushing case carefully and check it for transit damage and clean the bushing thoroughly.

(ii) Remove the locating pin. The cable bolt to be used on the unit is brazed to the end of the flexible draw through type lead mentioned above.

(iii) Remove the blanking plate and uncoil the daw through type lead. Tie the Flexible Steel wire to the head of the bolt fixed temporarily on the top of the cable bolt to facilitate the threading of the main lead through the bushing tube and at the same time preventing the lead from falling bank into the tank.

(iv) Suitably raise the bushing and remove the protective cover at the oil end of the bushing.

(v) Check that Oil Level in the bushing is appearing in the Oil Level indicating glass. In case it is not visible, do not mount that bushing. Also do not attempt to fill oil at site as such bushing is most likely to fail in service.

(vi) During the lowering operation, thread the flexible steel wire through the inside tube of the bushing and pull it. Continue the operation till the bushing rests on its flange pocket. Bolt the two flanges and remove the slings.

(vii) Hold the cable bolt in position, remove the flexible wire and insert the locking pin to hold the cable bolt remove the slings.

(viii) For removing air from the central tube after oil filling, unscrew the terminal cap and press the terminal bolt downward,

(ix) Fix upper and lower arcing horns and adjust the gap setting as per the required

Insulation Co-ordination.

g) CABLE BOXES:

Cable boxes are designed for receiving and protecting cable ends. Insulating paper is most hygroscopic and all paper insulated cable ends must be protected by suitable insulating compound. These cable boxes are provided with brass wiping glands and are designed with clearances inside the box suitable for compound filling. The cable box in such case must be filled with compound as marked as indicated in the drawing.

Cable boxes for PVC are XLPE cables are designed with air clearances and hence these boxes are not required to be filled with compound.

Cable boxes of 3.6 KV and above are provided with detachable gland plates. Earthing terminals are also provided on these cable boxes for earthing the armouring of individual cables.

h) BUSDUCT:

Some users prefer connections to load by means of busduct. Busduct is supplied by some other agency. However, we provide suitable flanges around transformers bushings for receiving the busduct.

The level of the busduct flanges from ground/rail level is indicated in the General Arrangement drawings of the transformer. The complete details of busduct flange is furnished by us giving complete dimensional details for the matching flanges, bolt spacing, bushing terminal details, etc.

i) MARSHALLING BOX:

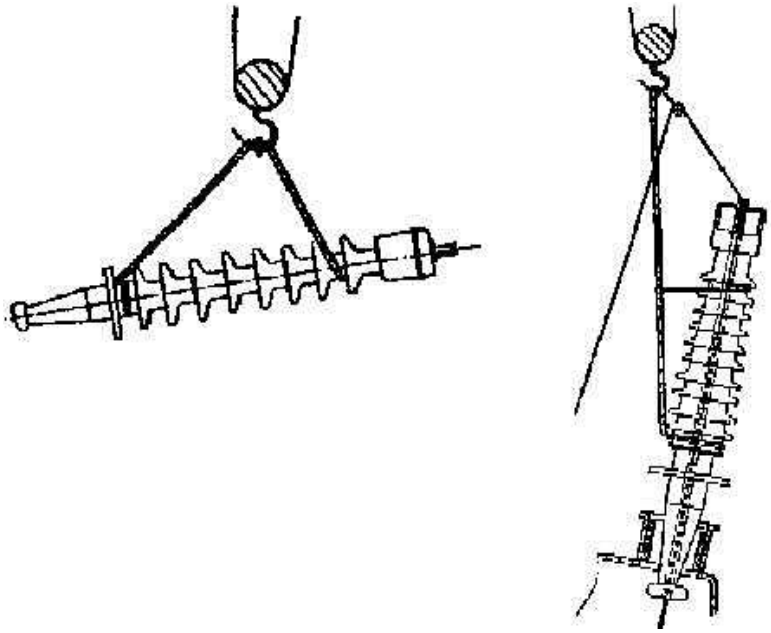
The transformer is provided with certain fittings directly mounted on the transformer at various locations. These fittings are having electrical contacts or terminals which are required to be connected to the protection schemes to give alarm/annunciation under abnormal conditions and if further required to disconnect the transformer form mains. In order to facilitate connections of all such devices to the protective scheme, the cable form all such contacts are wired up to a weather-proof terminal box, This box called marshalling box, is also used for housing Oil Temperature Indication (OTI) and winding Temperature Indicator (WTI).

The capillaries from OTI & WIT come out from the bottom of the Marshalling box through suitably recessed gland plate thus preventing ingress of dust.

It has a detachable gland plate with glands through which cables enter and leave. It has a rain shed provided on top to prevent rain falling directly over it. All these provisions make Marshalling

Box a Weather-Proof enclosure.

j) ERECTION OF HV TURRETS AND BUSHINGS



METHOD OF LIFTING CONDENSER BUSHINGS FROM PACKING CASE AND MOUNTING ON THE TRANSFORMER AT AN ANGLE

- Before starting the erection work of Condenser Bushing, lift the Bushing from its crate and keep it vertical and check the oil level. Confirm that oil level is up to the centre of oil sight window of Bushing.

→ If oil is drained from the tank a continuous supply of dry air should be ensured while removing the blanking plates and fixing the bushing turrets and bushings.Dry air shall have a dew point of -40^{O}C or better.

→ Total exposure time should not exceed 8 hrs. At the end of each day's work, blank off all openings and pressurise with dry air.

→ If weather is bad (rain, snow or fog) the tank should not be opened unless adequate shelter is provided.

→ For details of connections from winding to the bushing please refer to the specific drawing and suppliers catalogue given in the instruction manual.

→ Ensure that a fresh gasket is used while mounting the bushing.Ensure that the air release pipe connections are oriented towards the correct directions.

→ Bushing shall be mounted in the order of B, A, C or B, C, A.

→ While mounting the bushings, ensure that the oil level gauge is oriented away from the transformer.

→ While lowering draw lead type condenser bushing the cable shall be held tightly by using strong steel/plastic rope. Remember that dropping of cable can cause injury to the personnel and damage to the transformer.

→ Check and ensure that secondary terminal of turret mounted C.T. if any are connected to the proper terminals on the terminal board.

→ Check and ensure that secondary leads of C.T's. mounted inside the transformer are connected to the proper terminals in the terminal board.

k) TEMPERATURE INDICATORS

→ Sensing elements of oil and winding temperature indicators are to be fitted on to the thermometer pockets welded on the top cover of the transformer.

→ Before mounting the thermal sensing bulbs, inside of the pocket should be cleaned thoroughly and filled with transformer oil upto a depth of half the pocket.

→ Care should be taken not to damage the capillary tubing. Capillary tubes should be clamped properly.

→ RTD sensor element and heater coil are fitted on the cover.

→ CT leads shall be connected on one side and sensor leads are taken from the other side.

→ RTD instruments are mounted on the remote panel in the control room.

l) OLTC DRIVE MECHANISM

→ In case of on load tap changing transformer, the OLTC driving mechanism has to be mounted on the transformer. Please refer to the OLTC instruction manual supplied by the OLTC manufacturer.

→ Check for mechanical stops at extreme positions by manually operating with the handle.

→ Bring the tap position in DM to the tap position 1.

→ Connect 3-phase supply with correct phase sequence.

→ Check raise/lower operations. If direction is correct, check electrical end stops at extreme positions.

→ Different manufacturers of OLTC adopt different designs for the DM. Some manufacturers adopt dry type gear box for the motor and some manufacturers adopt oil filled gear box. Oil, if required, shall be filled as per the manufacturer's instructions.

→ Coupling up of drive mechanism and OLTC bevel gear shall be done only after ensuring that both are at the same tap position. Normally the transformer is despatched from the factory at rated Tap position.

→ Operate the DM manually from rated tap to tap no. 1 and then to the other extreme tap position and bring back to rated tap.

→ Operate DM electrically. Check and confirm that for each impulse given in both raise and lower directions, diverter switch operation sound is heard before the motor stops. After hearing the sound, the travel of the tap position indicating disc upto the green band shall be equal in both forward and backward crank operation.

→ Verify the ratios on all taps using ratio meter or digital voltmeter.

m) INSTRUCTIONS REGARDING USAGE OF GASKETS

- Gasket materials used are either Synthetic Rubber Bonded Cork (SRBC) sheet or nitrile rubber.SRBC material conforms to RC-70C of IS : 4253(Part II); thickness used are 6.0 mm and 10.0 mm. Gaskets should be stored in stress free condition and must be protected from moisture, oil and grease.

- Synthetic rubber bonded cork sheets once used should not be used again. Gasket seating surfaces should be smooth and free from scratches, oil, grease, dirt etc.
- Gasket should be properly located before tightening. Gasket joints are designed with 40~50% compression.
- Gasket joints should be tightened evenly with a diametrically opposite sequence.
- Over tightening will cause the gasket material to loose its properties and under tightening maynot prevent oil leakage.

n) CHECKING LEAK RATE UNDER VACUUM

- Drain oil & create vacuum of 200 torr inside the tank, close the valve between vacuum pump and tank and stop the pump and hold the vacuum. There should be no appreciable loss of vacuum over one minute.
- If there is leak, find out the leak and rectify.
- Start the pump and open the valves and continue till a vacuum of 10 torr is achieved. Close vacuums valve and stop the pump. There should not be an increase of pressure of more than 1 torr over half an hour.
- If the rise in pressure is more, find out leak and rectify.
- If results are satisfactory, restart the vacuum pump open the valves and continue pumping to obtain a vacuum of 1 torr or better and maintain this vacuum for more than 24 hrs. before and during subsequent oil filling operations.

o) INSULATION OF CORE AND FRAME TO TANK

→ If the internal body earthing lead is brought out through low voltage bushings, the megger values shall be measured using 2 kV megger and the values recorded.

p) VACUUM OIL INJECTION

→ Oil injection shall be made under full vacuum (1.0 torr or better) for transformers above 66kV. 380 mm Hg or better vacuum is required for transformers rated for 66kV and below. The vacuum shall preferably be measured by using McLeod Vacuum Gauge.

→ After draining the oil completely from the transformer, vacuum should be pulled from the oil filling hole on main conservator. If the conservator is fitted with air cell, pressure equalising connection is required to avoid damage to the air cell.

→ Before starting vacuum, all bolted connections shall be checked. Radiator valves shall be kept open.

→ A transparent vinyl hose shall be connected to the bottom sampling valve for indicating the oil level.

→ If explosion vent is provided, the pressure shall be equalised on either side of the diaphragm to avoid damage to the diaphragm.

→ Vacuum shall be maintained for 6 hours.

→ Oil may be injected through the bottom filter valve until the level reaches $35^{O}C$ marking on the Magnetic Oil Level Gauge of the conservator.

→ Natural rubber hose shall not be used as sulphur in the rubber may react with oil.

→ Oil inlet valve shall be closed and after one hour the vacuum shall be broken. Oil level indicating vinyl hose can be removed by closing the bottom sampling valve.

→ Vacuum gauges may be detached and breathers assembled in its position.

→ Pressure equalising connection provided for explosion vent diaphragm and OLTC diverter chamber shall be removed.

q) TOUCH UP PAINTING AT SITE

→ Any damage to the painting of the transformer and accessories shall be made good after erection work is completed.

→ If a welding has been done on the transformer at site, the paint film burnt by the welding shall be removed by wire brush or metal spatula. Remove the rust by wire brush and emery paper #80 / #100.

→ Wash away the oil, grease, dirt and dust by using suitable solvent and dry it up.

→ Polish the surface to be painted by using emery paper #80 /#100 and then clean the surface.

→ After cleaning, stir the ready mixed rust resistant primer paint 'Yellow Zinchromate' or 'Red Oxide' primer paint. Before applying the paint, confirm the correct viscosity.

→ Apply the paint uniformly by using a brush. drying time for the paint is normally 4 hours.

→ After the first coat of paint is dried up, mix and stir the finish coat paint to the desired viscosity and apply by brush uniformly. Drying time of finish coat paint is normally 6 hours.

→ Inspect the repainted surface and do re-painting if the painting is not uniform and unpainted surface is visible.

Recommended viscosities for painting :

(i) For brushing	: 50 ~ 55 sec.
(ii) For spraying	: 20 ~ 25 sec.
(iii) Pressure for spraying	: 55 ~ 60 psi.
(iv) Time gap between two coatings	: 24 Hours.
(v) Total dry film thickness after final coating	: as per data sheet (80 ~ 100 microns if not specified)

r) MIXING OF TRANSFORMER OIL

→ Some times a need arises at site to top up a transformer with oil of a different make.

→ New oil can be mixed with each other irrespective of the source or degree of refinement if both the oils meet the same standard specification.

→ Inhibited oils can be mixed only if the inhibitor used is same in either oils or the other one is uninhibited.

At any point of time, the percentage of new oil topped up shall be limited to 10% of the total oil quantity.

s) INSULATION DRY OUT AT SITE

HOT OIL CIRCULATION

→ Connect bottom filter valve of tank to inlet point of filter machine. Connect top filter valve of tank to outlet of vacuum filter machine and start oil circulation.

→ The filter outlet temperature should be limited to 60 ~ 70^{O}C.

→ Continue filtration for 4 cycles.

→ Oil circuit should include a vacuum chamber in which oil drawn from the transformer is sprayed and the moisture and gases are released from the oil are extracted by the vacuum pump.

→ A minimum capacity of 6000 litres per hour is recommended for the circulation equipment.

→ Cooler connection at inlet shall be kept closed to minimise loss of temperature during circulation. Outlet valve shall be kept open to allow expansion of oil inside the cooler.

→ Drain the oil by simultaneously admitting dry air or nitrogen gas from the top. This is to avoid winding insulation coming in contact with moisture.

→ Apply vacuum of 1.0 torr or better and maintain for 6 Hrs.

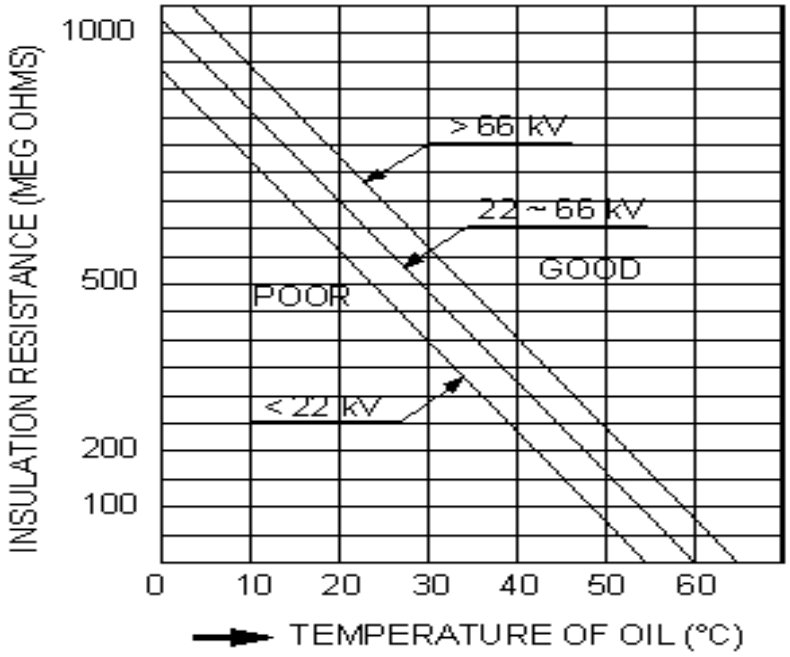
→ Inject oil under vacuum upto a level of approximately half of the conservator.

→ Start hot oil circulation again as explained earlier and continue for 4 cycles. Maintain temperature of 60 ~ 70^{0} C.

→ Drain oil by feeding dry air or nitrogen gas as explained.

→ Apply vacuum as explained. Repeat vacuum/hot oil circulation cycle till required dryness is obtained.

→ Normally 3 or 4 cycles of hot oil circulation and evacuation will be sufficient to obtain the required dryness for the insulation.



Variation of Insulation Resistance with Temperature

→ Dryness of insulation is determined by measuring insulation resistance of transformer winding.

→ Insulation resistance between each pair of windings and also between windings and earth shall be measured by using a 5 kV megger. Readings shall be comparable with the factory test results.

→ Direct heating of transformer is not recommended for dry out at site.

→ Oil samples shall be tested for moisture content, (Below 20/15/10 for 145/220/400 kV class respectively). Break down voltage (More than 60 kV at 2.5 mm gap). Resistivity ($\geq 10^{12}$ ohm meter) before final oil filling.

→ Do not measure insulation resistance when the transformer in under vacuum.

TRANSFORMER OIL PUMP

- The pump set is a single stage axial flow gland-less type, integral with the drive motor. It has been specifically designed for forced circulation of oil through the cooling system of large transformer & allows thermo phonic flow.
  - → It is designed for flange mounting directly to the pipe circuit of transformers in either horizontal or vertical position.
  - → All the moving parts are completely enclosed and gasket thus permitting open air installation, without any need for protective cover. It is compact in design.
  - → The Nameplate gives details of pump and motor output along with respective connecting pipe size.

SECTION – 4 ***PAGE NO.***

4) COMMISSIONING

4) COMMISSIONING

a) INSPECTION AND MAINTENANCE LOG SHEET

→ It is important that an inspection and maintenance log sheet be kept regularly. The original of this log sheet should be kept along with the Instruction Manual for future reference and record.

→ The log should include dates and details of all inspections and maintenance carried out.

→ Results of oil tests and insulation resistance together with the temperatures at the time of measurement should also be recorded in the log sheet.

→ Before commencing the test it should be ensured that the secondary terminals of all current transformers are kept short-circuited. After test these shorting connections shall be removed.

b) PHYSICAL CHECKS

→ Check oil levels in the level gauges of all condenser bushings.

→ All air release plugs shall be loosened and closed after releasing trapped air if any.

→ Check and confirm tightness of all fasteners.

→ Check and confirm that valves are either open or closed as indicated the valve schedule plate.

→ Check all bolted gasket joints and confirm that there is no oil leak.

→ All blanking plates and spares including spare gasket should be stored carefully for future use.

→ Check all cable terminations and ensure that cables are properly connected and cable numbering ferrules are provided.

→ Check and ensure that all protective covers like valve guards, LV bushing protection covers etc. are removed.

→ Check and confirm that all bushing porcelain are cleaned thoroughly and are without damage.

→ Check & confirm that the test tap caps of all Condenser type Bushings are tightened.

→ Remove the cap provided at the bottom of silicagel breather for the transportation purpose.

→ Arcing horns if provided are set to the specified gap

→ All earthing connections are tightened properly.

→ Anti condensation heaters are functioning correctly.

→ Rating and connection diagram plates and other marking labels are fitted properly.

→ All isolating switches are set at ON position.

→ Cooler control switch is set to AUTO.

→ All alarm circuits are reset.

→ OLTC to Transformer equalising pipe shall be removed after oil filling under vacuum and the opening shall be coverd by blanking plate supplied with the transformer.

c) INSULATION RESISTANCE CHECK

- Check and record insulation resistance between pair of windings and windings and earth using 5 kV Motorised megger megger and record the values at 15, 60 & 600 seconds.
- Calculate the ratios of insulation resistances IR 600/ IR 60 (Polarisation Index.) and IR 60/ IR 15. Compare the values with factory test results.
- Check insulation resistance between core and frame to ground if the earthing connection is brought out through bushings.

d) RATIO TESTS

→ Connect 3-phase 415 volts supply between HV terminals and measure the voltage ratios at all taps and record.

→ Earth connections from star point shall be removed during measurement and reconnected after tests.

e) VECTOR GROUP TESTS

→ Connect 415 V, 3-phase supply to HV winding terminals. The transformer shall be at rated tap.

→ Connect one HV terminal to one LV terminal and measure voltage between each HV terminal to each LV terminal in turn. Compare the values with factory test results.

f) MAGNETIC BALANCE TEST

→ Single-phase 240 volts is applied across any HV winding and voltage induced across the other phases are measured and compared with the factory test results.

CAUTION: ***If there is a residual magnetism in the core, it can give erratic readings.***

g) SHORT CIRCUIT IMPEDENCE

→ LV terminals are shorted by using suitable cables.

→ 3 phase 415 volts supply is connected to HV winding and HV exciting current of all the phases and LV circulating currents of all the phases are measured and recorded.

→ Percentage impedance = $\frac{\text{Rated current x Applied voltage x 100}}{\text{Measured current x Rated voltage}}$

→ Compare the results with factory test results.

h) WINDING RESISTANCE MEASUREMENT

→ Note down the oil/winding temperature. If the measurements are done after hot oil circulation; the oil/winding temperature may be different from the ambient temperature.

→ Measure the resistance of all windings using a Whetstone Bridge or Kelvin bridge. Convert the resistances to $75^{O}C$.

$$R(75) = \frac{R(\text{measured}) \times (234.5 + 75)}{(234.5 + \text{Oil temperature at the time of measurement})}$$

→ Compare the values with factory test results.

i) OPERATION CHECKS

→ Check direction of rotation of pumps and fans.

→ Check and confirm that flow indicators are mounted correctly.

→ Check signalling circuits for pump fail/fans fail etc., and reset.

→ Check setting of over load relays and reset.

j) BUCHHOLZ RELAY OPERATION

→ Check inclination of Buchholz relay pipe. The slope should be in upward direction, between $3^{O} \sim 9^{O}$ to horizontal towards the conservator.

→ Connect a compressed air line (Pressure 4 kg/cm^2) or a nitrogen cylinder to the petcock on top of the Buchholz relay. Open the petcock slowly and allow air to enter into the Buchholz relay.

→ Check the continuity of alarm contacts by using a multimeter.

→ Record the volume of air in the Buchholz Relay at which the alarm switch contact closes.

→ Close the air supply and release all the air by opening the other petcock on the Buchholz relay. Open the petcock quickly and allow air full flow with surge. Record the minimum pressure required to operate the surge contacts.

→ Release all the air trapped in the Buchholz relay.

SECTION – 5 ***PAGE NO.***

5) TRANSFORMER ACCESSORIES

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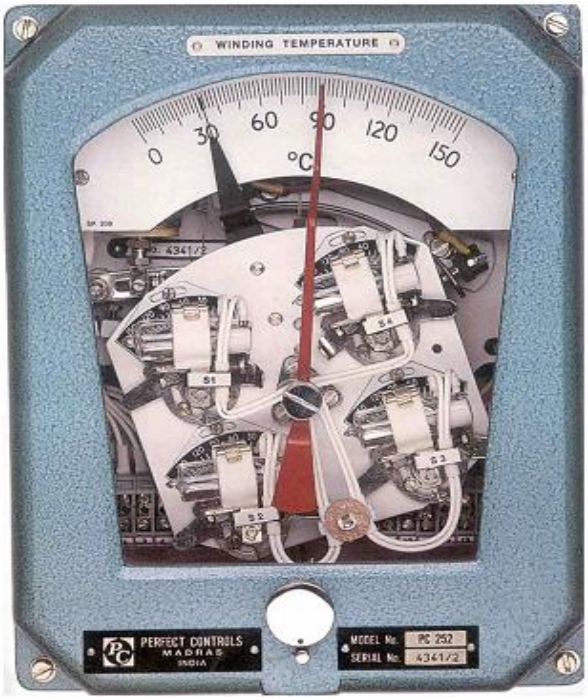


a) TEMPERATURE INDICATOR:

(i) INSTALLATION AND MAINTENANCE INSTRUCTIONS

- **APPLICATION**

The Temperature indicator is used as an Oil Temperature Indicator (OTI) or as Winding Temperature Indicator (WTI) for the protection of liquid immersed power transformer. In the case of dry type transformers it is used as Temperature Indicator (T.I.) to monitor the temperature of the windings.

(ii) SCOPE OF SUPPLY

- **OTI & WTI:** Instrument with specified Range, Number of control switches, length of capillary and sensing bulb.
- **TRANSMITTER (OPTIONAL):** A precision potentiometer is mounted inside the case of OTI or WTI to transmit the measured temperature to remote point(s).
- **REPEATER (OPTIONAL):** Analogue indicator supplied separately for remote indication of the temperature measured by OTI or WTI.

(iii) OPERATION

- The instrument operates as OTI when its sensing bulb is mounted in an oil filled pocket located in the hottest oil of an oil immersed transformer.
- The instrument operates as WTI when its sensing bulb is exposed to the medium adjacent to the windings of a dry type transformer.
- When a proportionate load current of the transformer is passed through the thermal image device, the instrument operates as a WTI integrating the simulated temperature rise of the thermal image device and the top oil temperature measured by the sensing bulb.
- Remote indication of the temperature measured by the OTI or WTI is provided by connecting the transmitter to the repeater either directly or through a resistance transducer (resistance to current converter).

(iv) CONSTRUCTION

- **LIQUID-FILLED SYSTEM:** A sensing bulb, a measuring bellows and a small bore capillary tube connecting the two, form the measuring system.
- A second bellows connected with a second capillary running parallel to the first capillary and terminated at the head of the bulb from the temperature compensating system. Both the systems are completely filled with the same liquid.
- The two bellows are linked to a compensating lever in such a manner that the effect of ambient temperature changes on the capillary line and measuring bellows is compensated.
- The movement of the measuring bellows is related only to the temperature being measured by the sensing bulb.
- This movement is amplified by the link and lever mechanism, which directly drives the rotating disc carrying the control switches. The same mechanism moves, through rack and pinion a separately mounted indicating pointer over a calibrated dial.
- Head compensation is provided by sealing both the systems under initial pressure, which is greater than the possible head pressure due to differences in the elevation between the bulb and indicator.

(v) **MAXIMUM POINTER (RED COLOURED):** located on the indicator lid, is resettable from outside the case by a screw driver blade. Unscrew and remove black cap to reach the screw driver-slot.

CAUTION: *Never use the switch testing knob for setting the maximum pointer. If used, the switch contacts will close and initiate the external control circuits when the instrument is in operation.*

(vi) **SWITCH TESTING KNOB:** It is fitted on the indicator lid to check mercury switches setting and potentiometer operation. These knobs when rotated moves the indicating pointer, switch mechanism and potentiometer wiper together and facilitates testing these circuits without opening the lid. Rotate the knob slowly and steadily for an accurate check. Never allow the knob to spring back suddenly or quickly, as this will cause damage.

(vii) **THERMAL IMAGE DEVICE:** A heater coil is fitted around the measuring bellow and supplied from a current transformer in the load circuit of transformer. The heater coil simulates hot-spot temperature of the winding over top oil temperature for a given load. The measuring bellows reacts to this simulated temperature rise in addition to the top oil temperature measured by the sensing bulb and the instrument functions as a WTI displaying the hottest spot temperature of the winding. An adjustable shunt resistor (17-calibrating shunt) is provided for shunting portion of the current through the heater coil to obtain precise thermal image.

(viii) **ELECTRICAL CONNECTION:** All internal electrical connection are wired to the terminal block mounted inside the indicator case. A wiring diagram is fixed inside the case of each indicator. Switches are identified by markings S1, S2, S3 and S4 on them. Terminal Nos. wired to each circuit are detailed below.

(ix) **GRADIENT ADJUSTMENT:** After opening the instrument lid, carefully remove the dial. Withdraw the calibrating shunt after removing the nut and retaining washer. One adjustable centre band and two fixed bands at the ends are provided in the shunt. One supply lead is connected to the centre band and the other lead to the lower band on the shunt. Slacken the screw in the retaining clip of the centre band. To reduce the temperature rise, move the centre band nearer to the lower band, to increase the temperature rise reverse the procedure. Retighten the screw on the centre band after

adjustment. Replace the shunt, dial and lid. Repeat the calibration, check after adjustments until the accuracy limits achieved.

(x) INSTALLATION MOUNTING: Mount the instrument in a vertical position. Otherwise errors, particularly in the horizontal plane, will upset the zero setting of the mercury switches. Place a sprit level on the top of the indicator case to ensure correct positioning and operation of the mercury switches. If vibration exists at the mounting position, mount the indicator on a non-vibrating structure. Suitable anti-vibration mountings are supplied. Do not use these mountings during transport.

(xi) CAPILLARY LINE: Do not stretch hard twist or bend the capillary to a radius less than 75 mm. Continuously support the capillary by suitable clips at intervals of 300 to 450 mm. Allow necessary slack at the bulb and for mounting and removing the bulb without sharp bend at the joint. Wind in spiral (minimum dia. 150 mm) the possible excess length of capillary close to the indicator or the bulb.

b) GAS OPERATED (BUCHHOLZ) RELAYS

i) PREFACE

One of the most essential devices to protect a transformer is a Buchholz relay. For more than 20 years, Buchholz relays have been manufactured in India. They are made by an experienced staff of skilled workers, highly qualified technicians and engineers ensuring a high degree of precision and quality.

ii) GENERAL

Power Transformers are considered to be a highly reliable type of equipment, yet, in order to ensure the continuity of service that modern conditions demand, protective devices are required. The purpose of such devices is to disconnect faulty apparatus before large-scale damage is caused by' fault to the apparatus or to other connected apparatus. Such devices generally respond to a change in the current or pressure arising from the faults and are used for either signalling or tripping the circuits.

Protective devices in the ideal case must be sensitive to all faults, simple in operation, robust for service and economically feasible. Considering liquid immersed transformers, a near-ideal 'protective device' is available in the form of Gas and Oil relay described here.. This gas is

collected in the body of the relay and is used in some way or other to close the alarm or the tripping circuit

The principle of the Gas and Oil relay was first successfully demonstrated and utilised by 'Buchholz' many years back.

iii) APPLICATIONS

Double element relays can be used in detecting minor faults in a transformer. The alarm element will operate, after a specified volume of gas has collected to give an alarm indication. Examples of incipient faults are –

- Broken-down core bolt insulation
- Shorted laminations
- Bad contacts
- Overheating of part of windings.

The alarm element will also operate in the event of oil leakage, or if air gets into the oil system.

The trip element will be operated by an oil surge in the event of more serious fault such as -

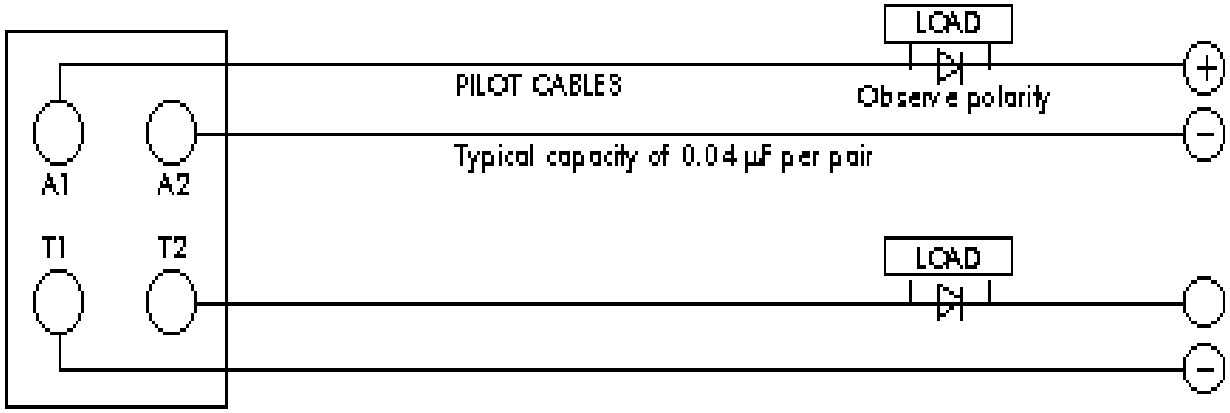
- Earth faults
- Winding short circuits
- Puncture of bushings
- Short circuit between phases

The trip element will also be operated if a rapid loss of oil occurs. Single element relays can be used to detect either incipient or major faults in oil filled potential transformers, reactors, capacitors etc. A special single element relay is available for the protection of on load tap-change equipment.

iv) SWITCH DATA:

Type	: Normally Open
Contact Rating	: 250 V A.C. (r.m.s.) or D.C. max.
Switching Current	: 5 A - A.C. or D.C. max.
Switching Voltage	: 300 V D.C. max---240 Volts A.C. (r.m.s.) max.
Breakdown voltage	: 650 Volts D.C. min.
Initial Contact Resistance	: 70 milli-ohms max.
Resonant Frequency	: Greater than 700 Hz.
Actuating Time	: 2 milli-seconds (Typical)

v) ARRANGEMENT OF TERMINALS AND MEANS OF PROTECTION FOR REED SWITCH CONTACT.



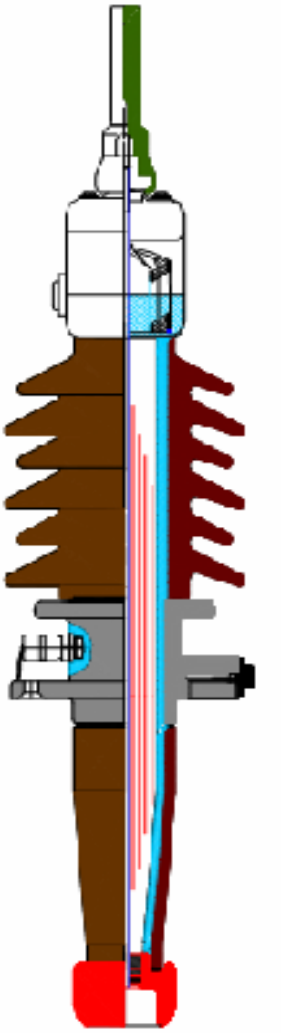
c) OIP CONDENSER TYPE BUSHINGS:

These instructions are crucial for the proper handling, installation, operation & maintenance of ***Oil Impregnated Paper Condenser Bushings*** *and these should be in the possession of those who are responsible for the above activities*.

INSTRUCTIONS FOR INSTALLATION, OPERATION AND MAINTENANCE OF OIP CONDENSER BUSHINGS

i) DESIGN AND CONSTRUCTION

- The general constructional details of the bushing, intended for oil-air application are shown in **Fig. 1**. The active part of the bushing consists of an Oil Impregnated Paper (OIP) core (1) manufactured from superior grade Kraft insulating paper with condenser



graded layers for field control, wound under tension on central tube / conductor (2).

- The innermost condenser layer is electrically connected to the central tube / conductor (2) and the outermost layer is electrically connected to the fixing flange (3) through a test tap (11). The core is dried under heat and vacuum and then impregnated with superior grade of insulating oil.
- Porcelain insulators (4&5) on the upper and lower sides of the bushing, oil resistant high quality rubber gaskets & 'O' rings (6) are held together with the central tube by means of a set of powerful springs (7).
- The fixing flange (3) is provided with a test tap (11) for the measurement of Capacitance and Tan delta, air releasing screw (10) to release the air trapped in the transformer during topping up of oil or can be connected to Buchholz relay, name plate giving the product details, handle / eyebolt for lifting and space for ring type CT's on the oil end of the bushing.
- At the oil end, an epoxy coated stress shield or base plate (15) is provided to control the high stresses in oil inside the transformer. A detachable bottom arc shield is provided for bushing rated 245 kV and above. The intervening space between the core and the porcelain insulators is filled with specially treated mineral oil under vacuum.
- A Prismatic (up to 300kV) or magnetic (up to 400 kV) Oil sight glass (14) is provided on the expansion bowl (8). A top terminal (12) is provided to connect to the over head line. Arcing horns (16, 17) are provided on request. (Ref. Fig. 3). Test Tap: - (Refer Fig. 2)
- The test tap (11) is provided for the measurement of Capacitance, Tan delta and Insulation Resistance (IR) values of the bushing. It is connected with a copper lead to the last condenser foil of the core directly. During normal service this test tap is electrically connected to the mounting flange through test tap cover. The threaded test tap cover must be fixed properly (Fig 2a) before putting into service.

ii) PACKING AND STORAGE:

- To prevent physical damage to the bushings, generally only one bushing is packed in wooden packing case. At times, more than one bushing is also packed in the case of bushings of lower voltage rating. The bushing is placed in the packing case at an angle

Fig : 1

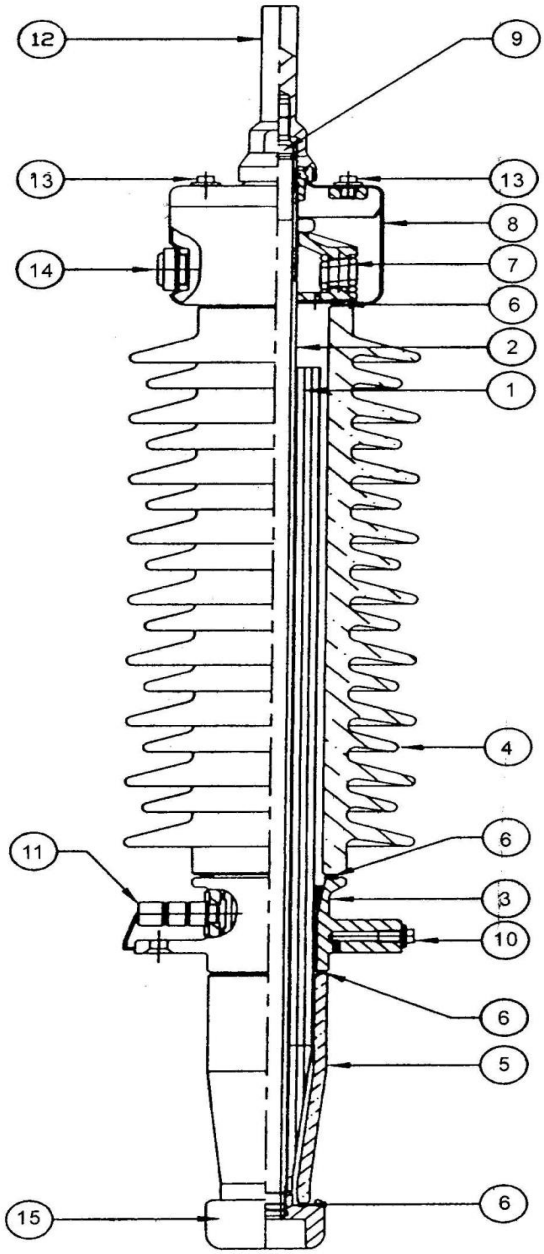


Fig : 2

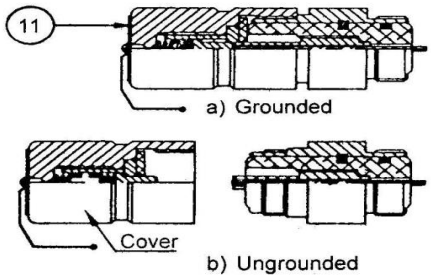
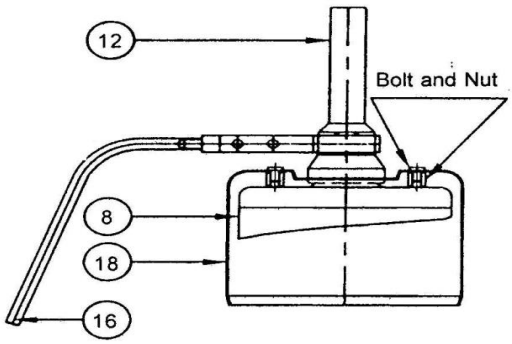
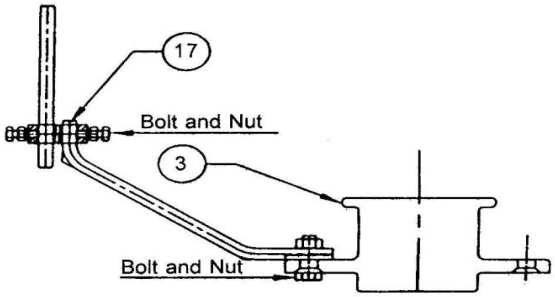


Fig : 3





1. Oil Impregnated Core
2. Central Metal Tube
3. Fixing Flange
4. Porcelain - Upper
5. Porcelain - Lower
6. Gaskets
7. Springs
8. Expansion Bowl
9. Cable Bolt
10. Air Releasing Screw
11. Test Tap
12. Top Terminal
13. Oil Filling Plug
14. Oil Sight Glass
15. Base Plate / Stress Shield
16. Upper Arcing Horn
17. Lower Arcing Horn
18. Top Shield Cover (Optional)

of 6-8 degrees to horizontal. Accessories like arcing horns, terminals etc. are also packed in the same packing case.

- This is to ensure the core remains immersed in oil. When the packed bushings are stored outdoors, they should be kept horizontal and covered with tarpaulin for protection from rain and other atmospheric contaminants.
- Measure the IR values of the bushing with a 2.5 kV megger.

  The recommended values are:

  → 4000 Meg ohms (Min) between oil end terminal or top and test tap.

  → 1500 Meg ohms (Min) between test tap and flange with 1 kV meggar.

The IR values may vary due to the atmospheric condition (humidity), surface cleanliness of the porcelains, dryness of test tap etc. In such cases, preheating of porcelains, terminals test tap etc., with hot air is recommended.

→ However, the healthiness of the bushings can be known only after measurement of Tan delta & capacitance values.

→ Capacitance and Tan delta values of the bushing should be measured between the top terminal and test tap at 2 kV to 10 kV (Maximum). The measurement should be preferably carried out indoors with RH not exceeding 60% and at ambient temperature, with the facilities and procedure as described as described below:

→ Schering Bridge

→ Standard loss free capacitor

→ High voltage supply

→ Necessary screened connecting leads.

Place the bushing vertically on suitable stand. Remove the threaded test tap cover. Insert a plug / clip into the central stud of the test tap and connect to the Schering Bridge through a screened cable. The flange body should be grounded. Connect the high voltage supply to the top terminal. Measure the capacitance & tan delta value of bushing up to a maximum of 10 kV.

Note: *The voltage applied on the bushing should be limited to 10 kV, when the bottom end is not immersed in oil. Utmost care should be taken to avoid any contact with the bushing during testing as this may result in fatal injury to the personnel.*

→ *The test tap should be dry, free from any moisture condensation and dirt deposition.The threaded test tap cover should be fixed back to the test tap, immediately after the test.*

→ Factory test values of tan delta and capacitance are indicated in the test report of individual bushing at working voltages. However, site values may vary, as they do not resemble factory test conditions.

→ The site values recorded at the time of commissioning should be taken as the reference values for comparison with future measurements. The bushing can be commissioned, if tan delta value measured is less than or equal to 0.007, and capacitance value as per the factory test value with maximum variation of 10%. If higher values are obtained, please contact ALSTOM, Customer Service Department giving full details of testing arrangement, for further advice.

Note: *The bushing should be kept vertical or mounted on transformer for a minimum period of 24 hours before application of voltage.*

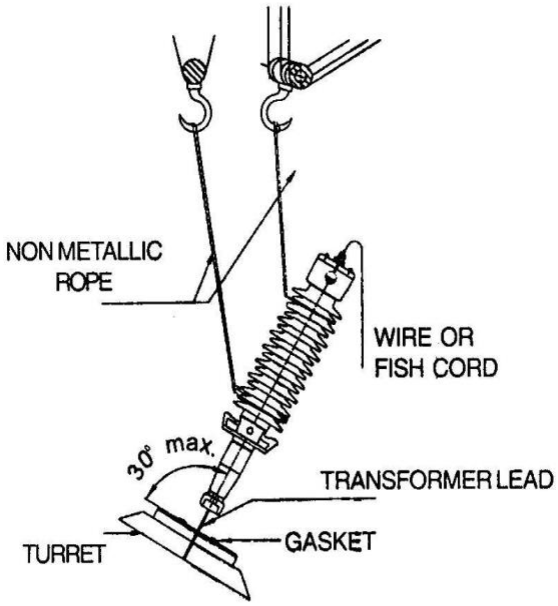


Fig : 8

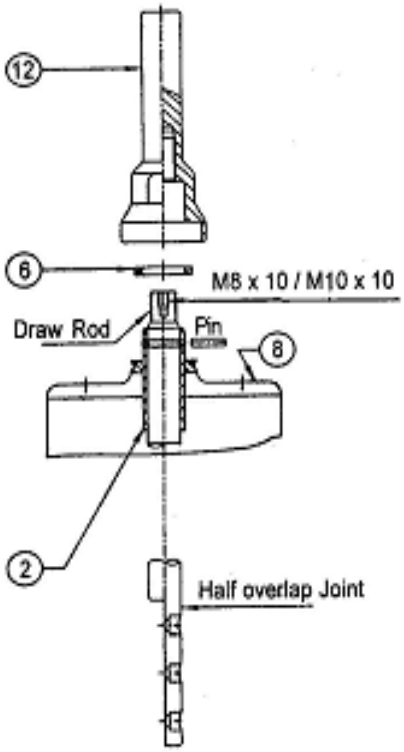


Fig - 10 (DR Type)

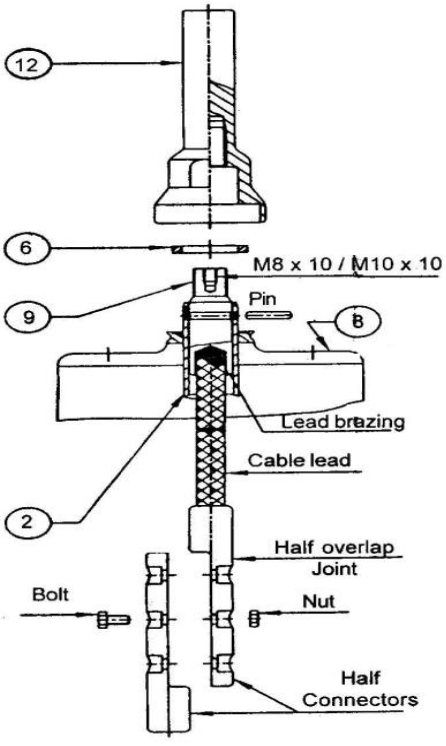


Fig - 9 (DL Type)

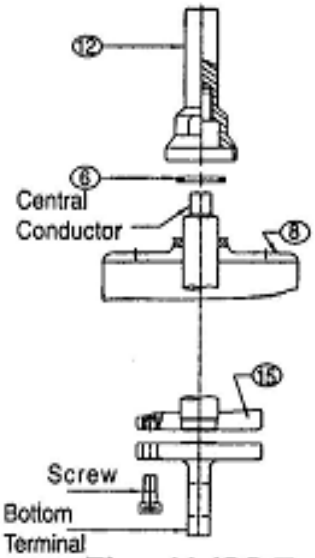


Fig - 11 (SS Type)

iii) INSTALLATION: (Please refer to Fig.8)

- The bushing is suitable for installation for a maximum angle of 30 degrees from vertical. During the lowering of the bushing into the transformer, extreme care should be taken to prevent the lower porcelain hitting the wall of the tank. The bushing should be so mounted on the transformer that the oil sight glass is visible from the ground level. Ensure the visibility of the oil level to the naked eye.
- Maximum stress experienced by the bushing is at the bottom stress shield during testing. Hence sufficient care should be taken to avoid any flashover from the stress shield to the wall of the turret. The flashover voltage depends on the clearance maintained in oil between the stress shield and turret, oil quality, surface smoothness, presence of barriers, shape of the stress shield and turret etc. The recommended size of the turret to be maintained for various voltage class of bushings is given in the manufacturer's booklet / respective drawings.

iv) BUSHING WITH DRAW LEAD CONNECTION: (Please refer to Fig.9)

- Each bushing is supplied with a top terminal (12), cable bolt (9), cable bolt pin and a gasket placed separately in the packing case.
- Drills a hole of suitable diameter based on the size of the flexible transformer cable at the bottom end of the cable bolt and braze the cable into it. Insert an M8 bolt at the upper end of the cable bolt and tie a wire or a fish cord on to it. Clean the gasket seating surface on top face of the transformer and place the gasket in position. Lift the bushing above the transformer turret and clean the bottom end of the bushing.
- Lower the bushing slowly into the transformer; simultaneously pull the transformer cable brazed with cable bolt through the central tube with the help of the fish cord. Secure the cable bolt to the central tube with the cable bolt pin. Remove the fish cord. Bolt the bushing into position taking care to correctly position the gasket joint. Tighten the terminal to the cable bolt ensuring full thread engagement for proper current transfer.
- Sometimes the cable bolt is supplied along with the brazed flexible lead up to the flange seat with a half connector at bottom end. In such cases the flexible lead from the transformer winding should be brazed to the other half connector and should be fastened with the draw lead connector of the bushing using bolts and nuts.

v) BUSHING WITH DRAW-ROD CONNECTIONS: (Please refer to Fig. 10)

- Bushings of higher current ratings are provided with draw rod type arrangement with a half overlap bolted joint at the flange seat.
- Remove the draw rod through the bushing tube or take it out from the packing case. Clean the outer surface and braze the transformer cable to the lower half connector. Clamp the upper and lower half connectors together with bolts and nuts. Follow the installation instructions as described for draw lead type of bushing.

vi) BUSHING WITH SOLID STEM: (Please refer to Fig. 11)

- In solid stem type of bushings, the central conductor forms the current carrying part. Mount the bushing on the turret and connections should be made to the top and bottom terminals individually. The transformer cable termination should be connected to the bottom terminal with bolts & nuts, through the viewing port of the transformer. The top terminal should be fixed directly to the central conductor.

vii) CHECKS AFTER INSTALLATION:

- After installation, clean the bushing thoroughly with a dry cloth and carry out physical inspection for any damage on the porcelain / leakage that might have occurred during installation.
- Check the oil level of the bushing.
- Ensure the top terminal is fixed tightly with the gasket provided to avoid entry of moisture in to the transformer.
- Measure and record the capacitance and tan delta values of the bushing. Here again the values may differ from the previous ones.

Note: *The threaded test tap cover should be fixed back to the test tap immediately after the test.The bushing should be kept vertical mounted on the transformer for a minimum of 24 hours before energisation.*

CAUTION: *THE TEST TAP WILL ALWAYS BE EARTHED AS LONG AS THE THREADED CAP IS FIXED (Fig. 2a). HENCE THE CAP SHOULD NEVER BE KEPT OPEN.*

viii) PERIODICAL CHECKS AND MAINTENANCE:

- As the bushing is a self contained unit, as such there is no specific maintenance to be carried out. However, a periodical check of the oil level and cleaning of the porcelain will normally suffice.
- In order to determine the healthiness of the bushing, measurement of capacitance and tan delta may be carried out during annual maintenance. These values are to be compared with the pre-commissioning test results. Tan delta value more than 0.007 and increase in capacitance by more than 10% or more, if observed, should immediately informed to AREVA for further advice.

SAFETY:

- Understanding the procedures and instructions are a must while handling bushings. Also, all applicable safety procedures such as regional or local safety rules and regulations must be followed. Safe working practices and good judgement are essential by the personnel while installing, testing, maintaining or disposing the bushings.

d) SILICAGEL BREATHER

SILICAGEL DEHYDRATING BREATHER FOR TRANSFORMER

- A dehydrating breather is used to dry the air that enters a transformer as the volume of oil decreases because of fall in temperature.
- Air entering the breather is first drawn through an oil seal and passes upwards through the silicagel crystals to the connecting pipe at the top. During this upward passage of air, any moisture present is absorbed by the dry silica gel.
- The oil seal ensures that the gel absorbs moisture only when the transformer is breathing.

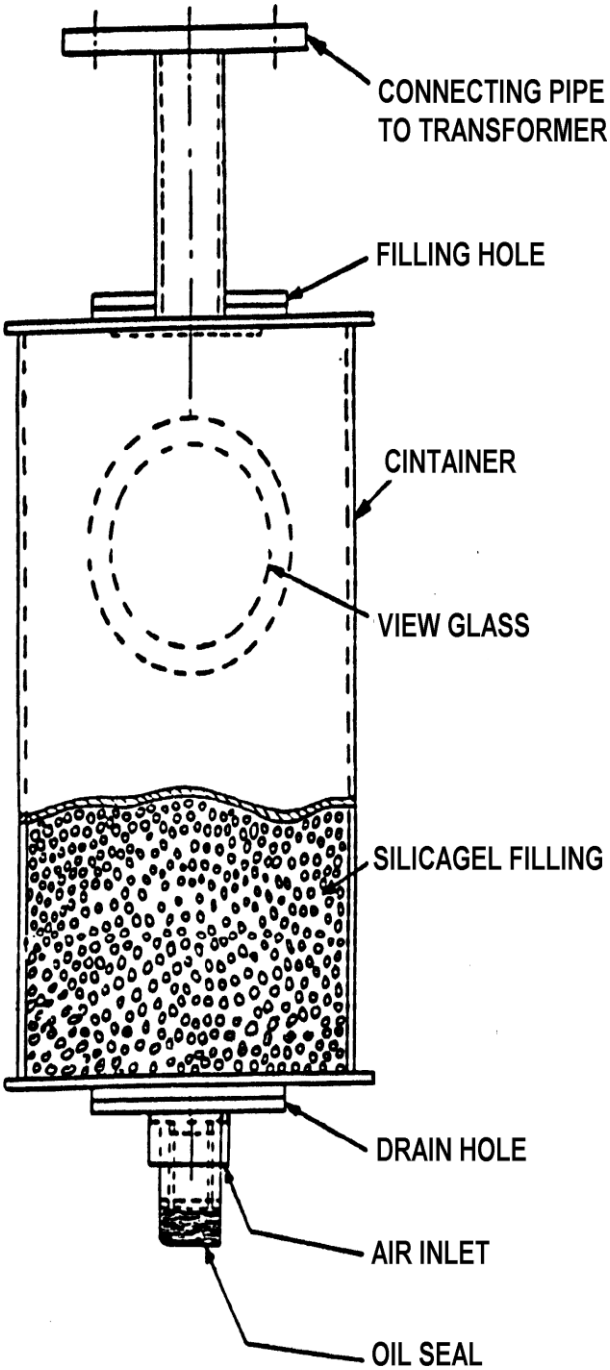
i) INSTALLATION

The breather is usually detached from the tank and shipped separately; the silica gel charge is shipped in at the top with a plug. To install, it is necessary to:

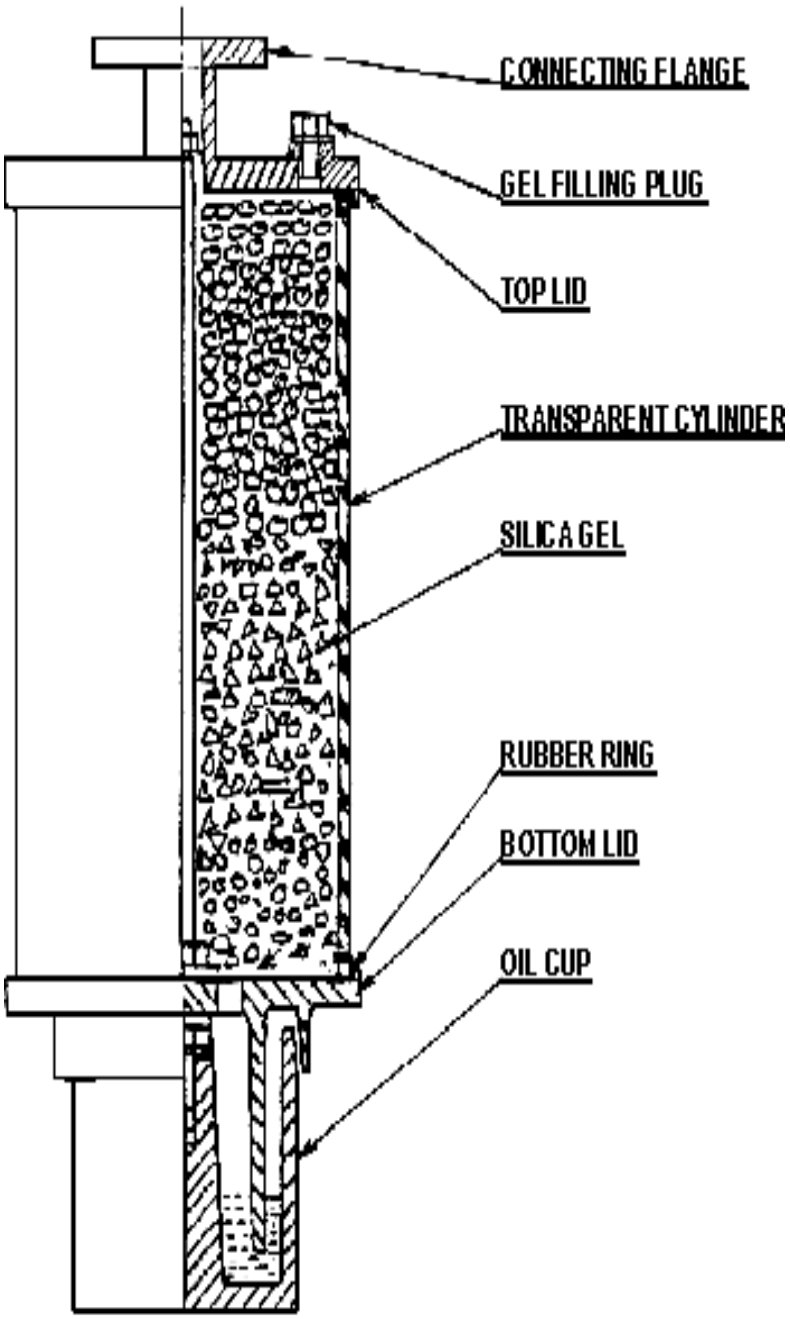
1. Remove top cover by unscrewing cap nut and fill with silica gel.
2. Remove the plug.
3. Pipe up to the tank or conservator.
4. Fill the oil cup with transformer oil to the indicated level.

ii) MAINTENANCE

- Inspect the breather on monthly basis; more frequently, if found necessary by experience (eg. highly humid atmosphere).
- When the breather is first installed, the crystals have a blue/orange tint, and after a period of operation, the colour of the tinted crystals gradually changes to pink/green; this is an indication that the silica gel is becoming saturated and losing its absorbent properties. When there is a preponderance of pink/green crystals the gel should be changed or reactivated.
- Silicagel may be reactivated by heating in a shallow pan at a temperature of 150° C to 200° C for two to three hours when the crystals should have regained their original blue/green tint.
- Before filling the container with silica gel, clean and dry all parts of the breather. Verify that the oil Level in the oil cup is correct when reassembling.
- Ensure that the breather is not choked and is free for passage of air.



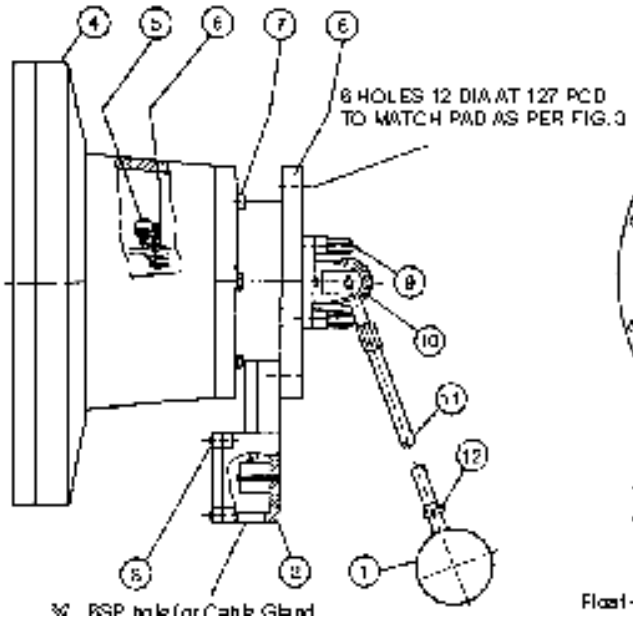
SILICAGEL BREATHER TYPE 1

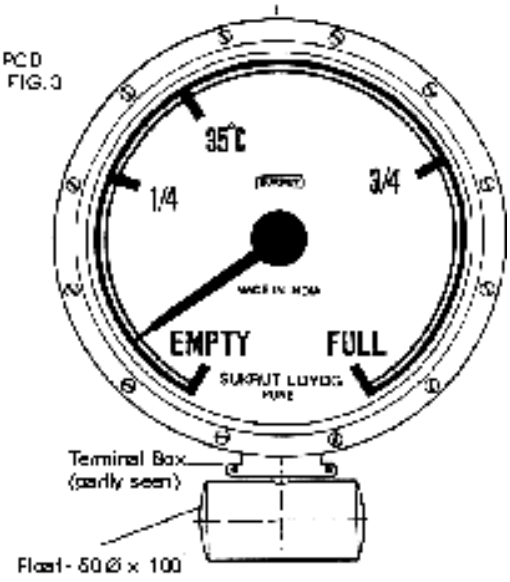


SECTIONAL VIEW OF BREATHER TYPE 2

e) MAGNETIC OIL LEVEL GAUGE: (MOLG)

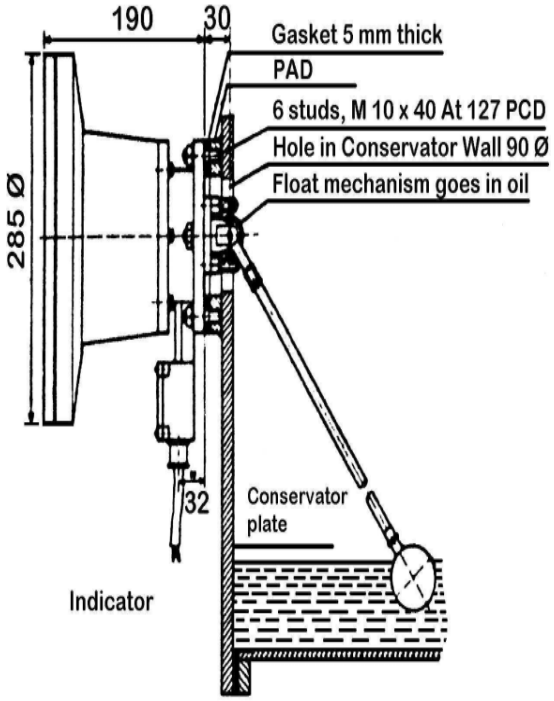
OIL LEVEL INDICATOR





SIDE VIEW **FRONT VIEW**

Fig. 2 INDICATOR SHOWN MOUNTED ON FLAT END PLATE OF CONSERVATOR



MOUNTING PAD Fig. 3

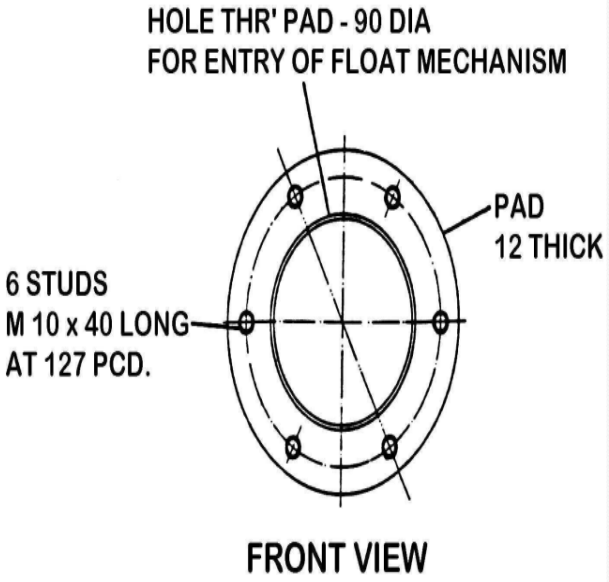
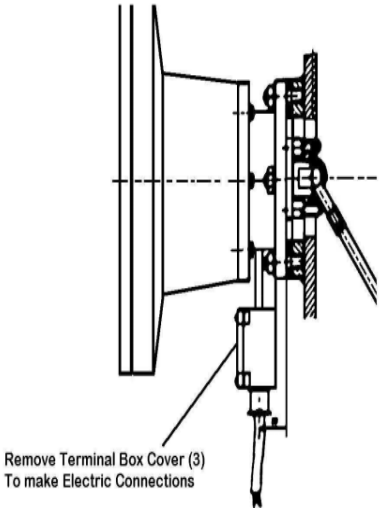
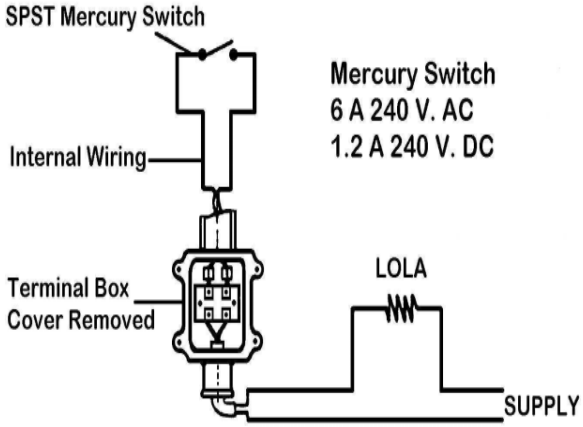


Fig. 4A



WIRING DIAGRAM Fig. 4 B



OIL LEVEL INDICATOR

- MODEL SO-03
- MODEL SO-06
- MODEL SO-10

i) APPLICATION

This model of indicator is manufactured considering Transformer application. It can also be used as Content Gauge on other tanks where level of liquid inside the tank is required to be indicated continuously on a dial.

ii) CONSTRUCTION, WORKING & FEATURES

- A float is used as sensor of liquid level inside the conservator (tank). Swing of hinged float due to change in liquid level is utilised to indicate level on a calibrated dial and to operate a switch for external alarm unit.
- Use of magnetic coupling in the indicator achieves complete sealing off of liquid inside the conservator from surrounding atmosphere. This result in avoiding any leakage of costly oil and avoiding contamination of insulating oil due to seepage of surrounding air in the conservator.

The glass mercury switch is nylon encapsulated to avoid breakage and spilling of mercury. Switch is accessible for servicing while indicator is mounted on the conservator without any necessity of draining the oil.

iii) CALIBRATION

The standard calibration of dial is Empty, 1/4, 1/2, 3/4, Full. Calibration of marks Empty & Full is done after leaving 65 mm from bottom and top of conservator to avoid striking of float to conservator wall. Different calibrations are done to suit customer's needs.

iv) MOUNTING

In fig. 2, indicator is shown mounted by keeping dial and mounting pad in vertical position. However, indicator can be mounted in titled position towards ground (max 30°) for easy viewing by fixing mounting pad at desired angle. The position of indicator on the conservator can be selected to suit site condition. Float mechanism passes through the hole in pad.

v) ALARM SWITCH & CONNECTIONS

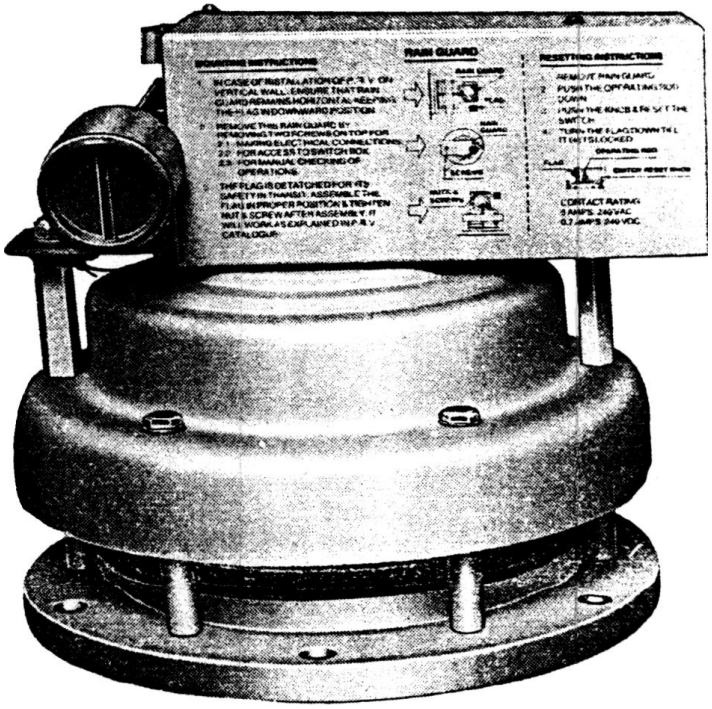
One mercury switch is provided for Low Level Alarm. The Normally Open switch closes when oil level drops to 10 mm above Empty level i.e. 75 mm from bottom of conservator. Leads from

mercury switch are brought into a terminal box positioned at the bottom of indicator (see Fig. 4B), A two-way terminal strip is provided which is accessible for connection after removing cover of terminal box. A hole with 3/4" B.S.P. is provided for cable gland. Wiring should be done as per Fig. 4B.

vi) SPECIFICATIONS

Operating Liquid	:	Transformer Oil to IS: 335
Working Temperature	:	0 to 100° C of Oil
Working Pressure	:	0 to 4 kg/cm²
Environment	:	For Indoor & Outdoor use
Weight	:	6.6 Kg. with Float & Float-arm
Float Travel	:	Float moves in right angle plane to seating face (See Fig.2)
Electrical witch	:	One SPST Mercury Switch
Contact Rating	:	5 Amp 240 V.AC. 50 Hz., 1.2 Amp. 240 V.DC.
Switch Setting	:	Normally Open Closes when oil level drops to Empty level. Switch opens automatically when oil level rises.
Dial Size	:	250 mm dia.
Dial Position	:	Vertical or Inclined
Conservator diameter	:	Available for use in range of 600 to 1500 mm dia.

f) PRESSURE RELIEF VALVE



- MODEL:- T-3
- MODEL:- T-5
- MODEL:- T-6

i) APPLICATION:

This PRV is designed to be used on Power Transformer. When pressure in the tank rises above predetermined safe limit this valve operates and performs following functions.

- Allows the pressure to drop by instantaneously opening a port of about 150 mm diameter.
- Gives visual indication of valve operation by rising a flag.
- Operates a micro switch.

This switch has 1 NO and 1 NC contacts (Four terminals). Hence switch can be effectively used in control circuit.

ii) CONSTRUCTION & WORKING:

- This PRV has an integral flange with six holes for mounting. The valve can be mounted vertically or horizontally on the tank. The PRV has got a port of about 150 mm dia. This port is sealed by a stainless steel diaphragm.
- The diaphragm rests on an 'O' ring and is kept pressed by two heavy-duty springs, thereby keeping the port closed. The other side of the diaphragm is exposed to tank pressure. Whenever the pressure in the tank rises due to any reason, the same pressure acts on the diaphragm from inside. When pressure rises above predetermined safe limit the diaphragm gets lifted from its seat.
- This lifting is instantaneous and allows vapours, gases or liquid to come out of tank depending upon the position of valve on tank.
- The diaphragm restores its position as soon as pressure in the tank drops below set limit. The lift of the diaphragm is utilised to operate flag and micro switch with the help of rod. The flag and switch remain operated until they are reset manually.

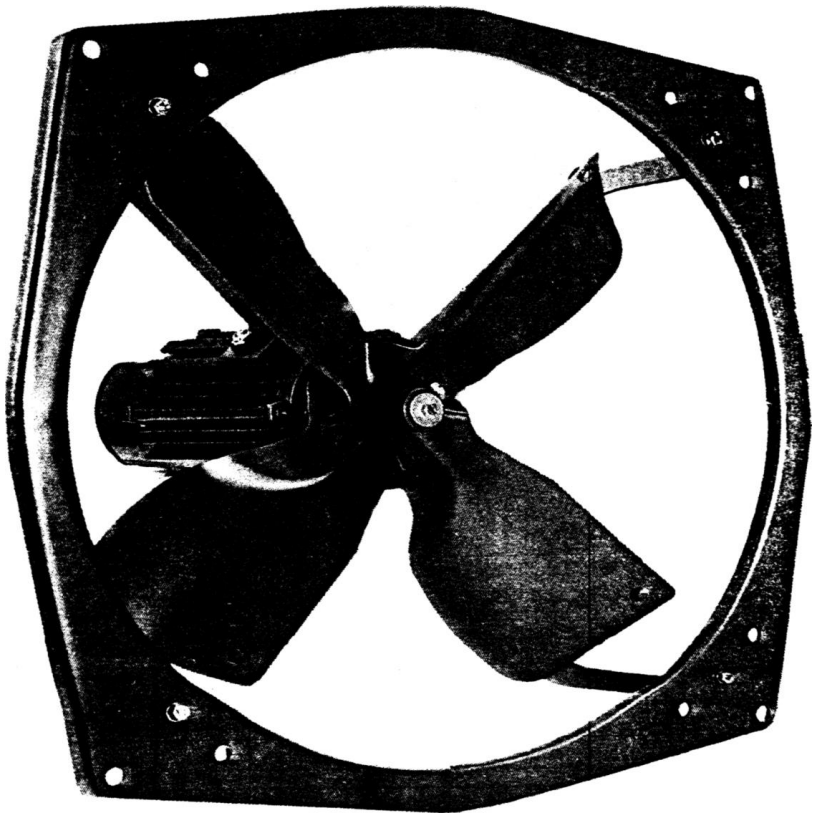
iii) CHECK FOR VALVE:

- Remove the cover of switch box. By lifting the operating rod check operations of switch as stated in Test 4 in test certificate with the help of an AVO meter. After checking, reset the switch by pressing knob. Replace the cover.
- The flag operation should be checked manually by lifting the rod. Reset the flag by turning it down. Handling of flag should be done very carefully.
- The product label indicates the suitability of valve for synthetic liquid or for transformer oil. A proper valve should be selected. Normally Red product label is used for synthetic liquid and Black label for transformer oil.
- A Gasket for base is supplied with each valve.

iv) FAULTS AND REMEDIES:

- The valve has rugged construction and it is not likely to get damaged easily. However, the indicating flag is delicate item. Hence if is likely to get damage.
- The indicating flag can be replaced by either making similar flag at your end or by asking for replacement.
- You can repair with the help of good instrument mechanic minor faults occurring in working of switch or flag mechanisms.

g) COOLING FANS



i) GENERAL

Exhaust type cooling fans used on transformers are designed to operate outdoors in all weather conditions. Generally the following sizes of fans are used.

Sr. No.	Size (mm)	Speed (r.p.m.)	Input (watts)	Phase	Voltage (volts)	Frequency (Hz)	Current (Amp)
1	610	700	240	3	415	50	0.5
2	610	900	500	3	415	50	0.9

The fans are designed to operate outdoors in all weather conditions.

ii) MOTORS

The fans are powered by totally enclosed, squirrel cage induction motors. The motors are adequately rated to give reliable service for many years.

iii) IMPELLER

The impeller is designed to give maximum volume at minimum noise level with minimum power consumption.

For reducing vibrations, special shoes made of rubber are provided at fixing points of fan lugs.

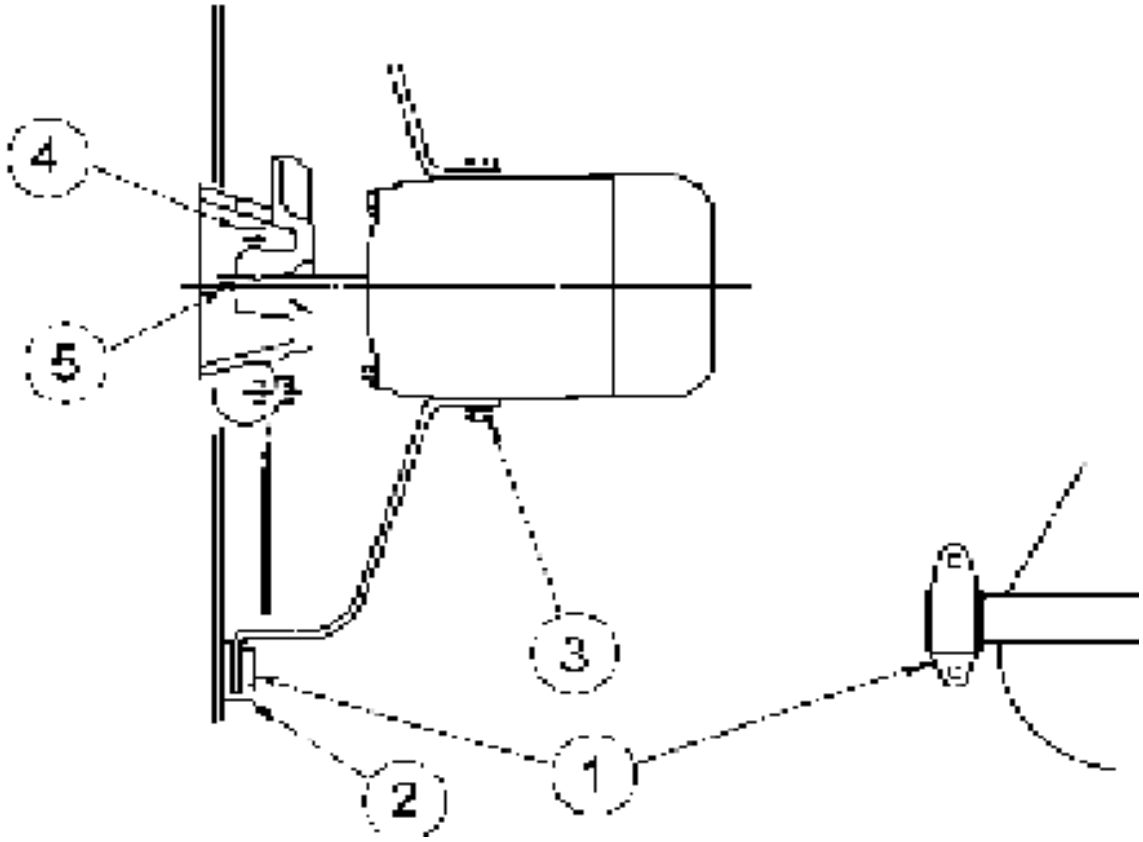
iv) MOUNTING

The arm is secured by the resilient mounting caps, which are placed over the rubber sockets and secured to the diaphragm with 8 screws, nuts and washers provided. The lock washers should be fitted under the heads of the screws.

Rubber sockets fitted to arms. To be fitted so that flat side will come in contact with the diaphragm.

NOTE: Lock washers are supplied and should be fitted.

Setscrew in blade should engage in dimple nearest the end of the shaft. After blade is fitted, see that split pin 5 is replaced in end of shaft.



h) FLEXIBLE SEPARATOR (AIR CELL)

i) INTRODUCTION

- Flexible separator (Air Cell) is provided inside the conservator of power transformers for avoiding direct contact of air with the transformer oil. Air Cell provides a permanent, flexible and non porous barrier between the atmosphere and the transformer oil without affecting the operational function of the system.
- The basic construction of the separator is a highly resistant fabric coated externally to resist transformer oil and internally to Ozone and weather resistant.
- Flexible separators offer the following advantages :-

  → Avoids contact between air and oil and consequently of condensation or oxidation inside the transformer.

  → Protection against water vapour and gases.

  → Suppression of any gas bubble formation in oil.

  → Compensation of large volume changes.

ii) DESCRIPTION

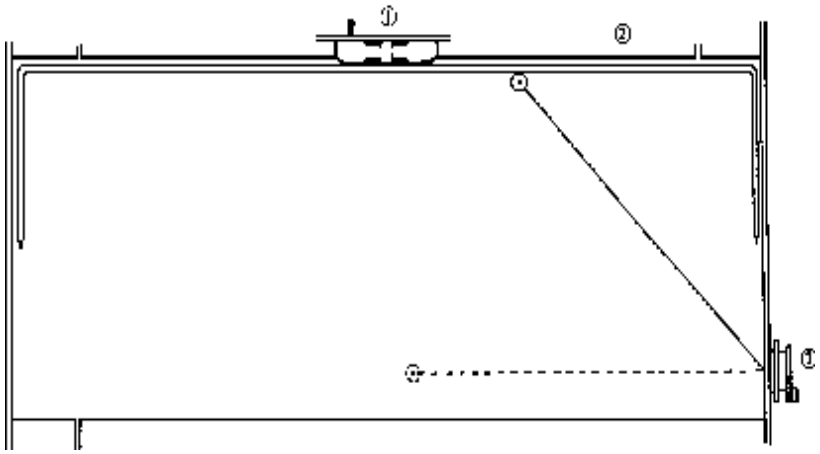
Flexible separator is fitted inside a cylindrical conservator. Oil being outside, the separator is in direct contact with atmosphere. This type of mounting makes it possible to compensate for the oil volume displacements due to temperature variations.

iii) CHARACTERISTICS OF MATERIAL

- Flexible separators are made from coated fabric consisting of: Textile reinforcement i.e. highly resistant polyamide fabric.
- External coating chemically resistant to transformer oil.
- Inner coating resistant to Ozone and all weather conditions.
- Major characteristics of materials are listed below:

→ Mass	—	1400 ± 140 g/m²
→ Coating	—	Poly acrylonitrile butadiene
→ Textile reinforcement	—	Polyamide
→ Breaking Strength before immersion in oil	—	> 300 daN / 5 cm.

iv) INSTALLATION PROCEDURE



1 Connection to the inside of Air Cell

2 Connection to the inside of Conservator

3 Magnetic Oil Level Gauge

Mounting Of Air Cell and Oil Level Gauge In Conservator

Details Of Fixing Air Cell On Conservator

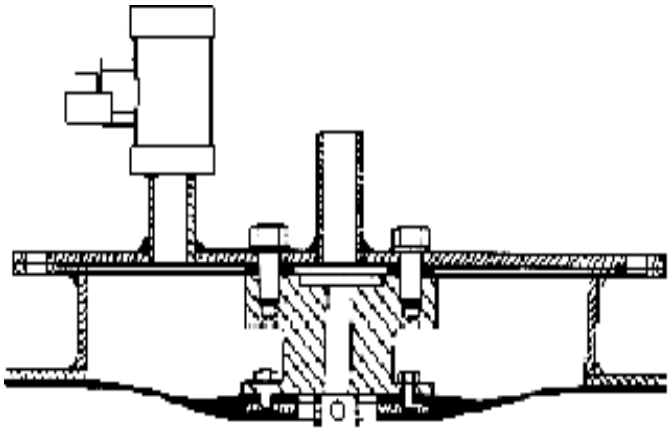


Fig. 2

Details Of Hook On On Conservator And Handle On Air Cell

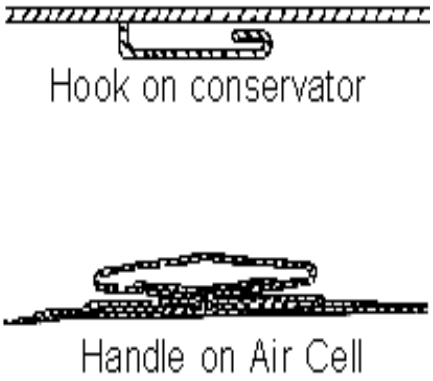
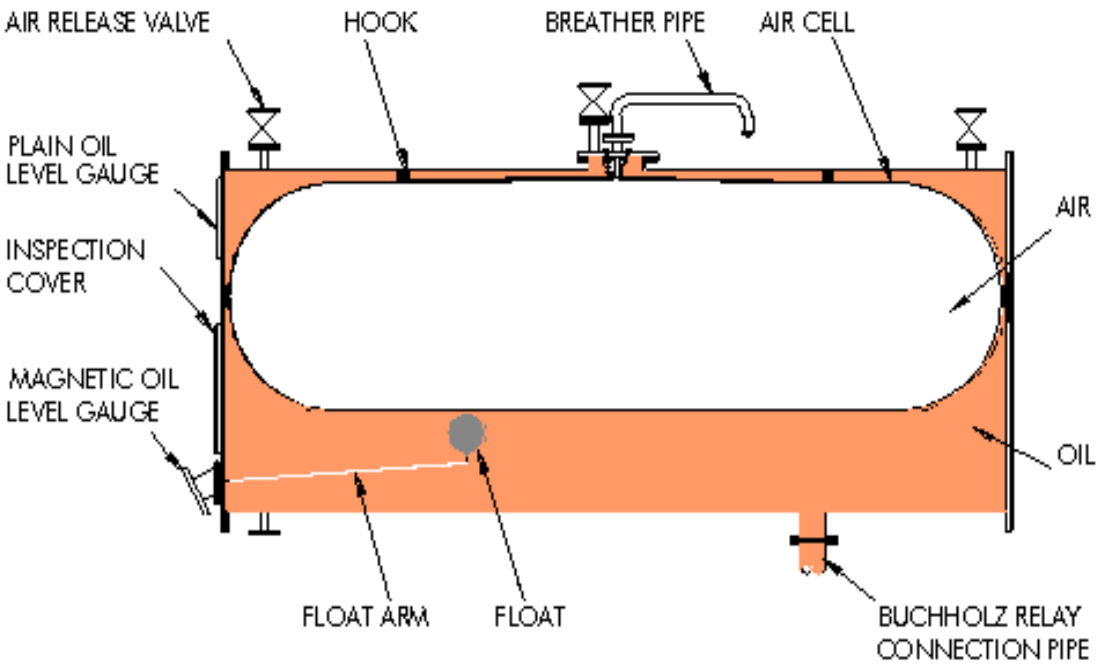


Fig. 3

v) FILLING PROCEDURE WITHOUT VACUUM IN CONSERVATOR



- The conservator with Air Cell is pressure tested and despatched from the factory at a slightly positive pressure. Confirm that there is no oil leakage.
- Fix three numbers air release valves on the conservator.
- Keep air release valves open. Fix air filling adapter on breather pipe and inflate the air cell at an air pressure indicated on the INSTRUCTION PLATE affixed on the transformer and hold air pressure.

DO NOT APPLY EXCESS AIR PRESSURE AS IT MAY DAMAGE THE AIR CELL.

- Open air release valves and start oil filling from the bottom of the conservator.
- Observe the air release valves and as soon as oil starts overflowing, close the air release valves one by one. Stop oil filling when all air release valves are closed.
- Remove the air filling adapter.
- Continue oil filling and observe the Magnetic Oil Level Gauge (MOLG)

- Stop the filling when the needle of MOLG shows the level corresponding to the ambient temperature at the time of filling.
- Fix silica gel breather.

FILLING PROCEDURE UNDER VACUUM IN CONSERVATOR

The conservator, with its separator, being set up and plugged in above the transformer, is connected to its oil filling reserve by a pipe in its lower part.

Proceed as follows:

- Create a vacuum in separator.
- With the same source of vacuum, create a vacuum in the conservator.
- Open the oil filling valve of the transformer.Because of the vacuum in the conservator, the oil level rises automatically.
- Stop the oil filling once the required volume in the conservator is attained.
- While maintaining the conservator under vacuum, allow Dry Air or Nitrogen gas to enter into the internal part of the separator. Then, the separator inflates by itself, and takes all the free space due to the fact that the conservator was not completely full. In particular, during the operation, the oil is going to rise to the top of the conservator.
- Inflate the separator at a maximum as shown in the INSTRUCTION PLATE.
- Check on the vent-holes, and confirm that there is no more air in the conservator or, if necessary, adjust the level.

vi) EXPLOSION VENT

The diaphragm fitted at the exposed end and inner of the vent should be inspected at frequent intervals and replaced if damaged. Whenever lower diaphragm of double diaphragm explosion vent ruptures, oil rises inside the explosion vent pipe and is visible in the level indicator on explosion vent. Failure to replace the outer diaphragm quickly will allow ingress of moisture which will contaminate the oil. If diaphragm is broken because of fault in the transformer, an inspection should be carried out to determine the nature and cause of the fault.

- **CARE AND MAINTENANCE OF DIAPHRAGM**

→ The diaphragm fitted at top end of explosion vent, must be inspected for any sign of damage before the transformer is commissioned.

→ If diaphragm is found damaged it must be replaced immediately to avoid iol contamination with moisture.

→ When the explosion vent is fitted with an air released plug of pet cock, it is recommended to keep it open while filling oil is conservator and must be closed after oil filling operation is completed.

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6) ENVIRONMENT, HEALTH & SAFETY MATTERS

Even though the manufacturer of the transformer has put every effort to comply with the rules and regulations applicable to the safe operation of the transformer, the equipment described in this manual is safe to use provided that:

- It is installed in a location suitable for its designed purpose.
- The installation is done by qualified and competent persons.
- The installed equipment is operated and maintained in accordance with the manufacturer's instructions by qualified and competent persons familiar with the type of equipment involved and its working environment.
- All work is done competently and in accordance with good engineering practices and in a manner, which is not hazardous either to personnel or to equipment.
- The recommended pre-commissioning checks are done before energising the transformer.
- The operation of protective systems and devices for the transformer are checked regularly.
- Neglect or deliberate overriding of protection system or device could allow a minor problem to develop into a major problem resulting in total loss of the transformer, damage to other equipment and injury to personnel.
- Prolonged operation under over load, over voltage or over excitation condition can have a seriously detrimental effect on the life of equipment. The pressure relief devices are designed to eject liquid, which is likely to be very hot in the event of a fault developing within the transformer.
- Equipment such as pressure relief devices incorporates heavy springs in compression. If the equipment is dismantled without due safeguard, damage and /or injury may result.
- The internal atmosphere of a transformer tank, if N2 filled, is replaced by breathable dry air of dew point less than -40^0 C for a minimum period of twenty four hours.

a) ELECTRICAL SAFETY

The following hazards are commonly associated with the installation, operation and maintenance of electrical equipment

- Existence of AC and DC voltage.
- Possible existence of toxic hazards associated with material used in the construction of electronic components, cleaning agent and solvents.
- Electric shock due to incorrect earthing, moisture on insulation, bad engineering or working practices.
- Fire or burn out due to incorrect setting or over load or protective devices, incorrect cables or fuses, insufficient ventilation or incorrect operating voltage.
- Short circuit flash over due to dust or moisture on insulation or short circuit on live conductors.
- If the secondary of a current transformer is disconnected, a dangerously high voltage can be induced in the circuit. If the secondary circuit of a current transformer is to be disconnected it must be shorted by a link capable of carrying the rated current.
- Do not apply any voltage or even high voltage megger when the equipment is under vacuum.

b) HAZARDOUS SUBSTANCES

- **TRANSFORMER OIL**
  - Normally, transformer oil presents no hazard to health. However, serious neglect may affect the skin and cause irritation.
  - Oil is a hydrocarbon and will burn. Carbon dioxide, dry chemical, foam or water fog is the extinguish ants.
- **MERCURY**
  - Mercury switches or thermometers containing mercury should be handled carefully. Mercury vapour can be hazardous over a period of time, especially in poorly ventilated room.

c) ENVIRONMENTAL HAZARDS DUE TO OIL SPILLAGE & FIRE CONSEQUENT TO FAILURE OF TRANSFORMER AT SITE

Oil spillage from Transformer tank, bushing, pipe joints etc. may cause the source of major fires. It is recommended that Transformer shall be inspected daily for the oil spillage.

The general CBIP recommendations for the Transformer installation are:

- → Soak pits
- → Drain pits
- → Barrier walls
- → Fire detection system
- → Fire hydrant system

d) CONTROL OF OIL SPILLAGE

- Responsibility: Respective operator of Sub station
- Keep a track of the maintenance schedule of Transformer & ensure that the required routine & preventive maintenance are done as per the schedule
- On noticing any leakages from the Transformer immediately place a tray /container to collect the spillage and inform the maintenance department for immediate corrective action (for example replacement of gasket etc.). Oil shall not be allowed to fall on to ground.
- In case any leakage to ground take place, remove the same with cotton/cloth/ saw dust.
- In case large scale spillage immediately inform the shift in charge & start collecting the spilled oil to suitable container and assess the risk of continuous operation of the Transformer

e) CONTROL OF FIRE

It is necessary to check the healthiness of the Transformer fire protection system regularly so that the fire risk can be minimized

- There shall not be any oil leakage.
- During hot oil circulation in the Transformer keep fire extinguisher ready near the Transformer, all the combustible materials shall be kept at a safe distance.
- Terminal connector, Fuses shall be checked against spark.
- Condition of Transformer oil shall be checked regularly

- Proper Housekeeping near Transformer may help to reduce the risk of fire.
- Proper fire fighting system as per CBIP recommendation shall be installed near Transformer. Regular inspection & maintenance to be done on the Fire fighting system.

f) PRECAUTIONS AGAINST FIRE

- Welding on oil filled Transformer shall be carried out if unavoidable, as per the instructions of the Manufacturer.
- Hot oil circulation shall be carried out only under the round the clock supervision to prevent chances of fire on lagging materials etc.

g) DO'S AND DON'TS FOR SAFETY MEASURES / PRECAUTIONS

- **DO'S**

  - Insulating oil and insulation of windings and connections are inflammable. Watch for fire hazards.
  - Before entering inside the Transformer, replace Nitrogen gas completely with air if it was transported with nitrogen gas inside.
  - Make sure that nothing is kept inside the pockets before one enters inside the main unit. Also take off the wristwatches and shoes.
  - List up all the tools and materials to be taken inside and check it after coming out to make sure that no tools are left inside.
  - There must be a protective guard for lamp to be taken inside.
  - Keep inspection covers open for supply of fresh air when someone is working inside.
  - When one person is working inside, second person must be available outside for emergency help.
  - Use rings spanners and tie them to the wrist of the person or somewhere outside the tank.
  - Be careful during connections where bolted joints are involved so that nut, washers etc. are not dropped inside the tank.
  - De-energise the unit by circuit breakers and line switches while working on energised unit.
  - Check the diaphragm of explosion vent and replace it if cracked.
  - Attach the caution tags "DO NOT OPERATE THE SWITCHES" while working on units, which are energised.

- Fire fighting equipment should be checked regularly and should have sufficient quantity of extinguisher.
- Transformer tank, control cabinets etc. as well as oil treatment equipment shall be connected with permanent earthing system of the station.
- Check and thoroughly investigate the transformer whenever any alarm or protective device is operated.
- Check air cell in conservator.
- Attend leakage on the bushings.
- Examine the bushings for dirt deposits and clean them periodically.
- Check the oil in transformer and OLTC for dielectric strength and moisture content and take suitable action for restoring quality.
- Check the oil level in oil cup and ensure air passages are free in breather. If oil is less make up the oil.
- If inspection covers are removed or any gasket joint is to be tightened, then tighten the bolts evenly to avoid uneven pressure.
- Check and clean the relay and alarm contacts. Check also their operation and accuracy and if required change the setting.
- Check the protection circuits periodically.
- Check the pointers of all gauges for their free movement.
- Clean the oil conservator thoroughly before erecting.
- Check the OTI and WTI pockets and replenish the oil if required.
- Gas filled storage of transformer at site should be limited to a maximum of 3 months.
- Check the door seal of the Marshalling box. Change the rubber lining if required.
- Ensure proper tightness of top terminal of condenser bushings to avoid entry of rainwater.
- Check oil level in condenser bushing, any discrepancy should be reported immediately to the manufacturer.
- Do jacking only at jacking pad.

- **DON'TS**
  - Do not take any fibrous material such as cotton waste inside while repairing.
  - Do not drop any tools / material in side.
  - Do not stand on leads / cleats.
  - Do not weld, braze or solder inside the tank.
  - Do not weld anything to the tank wall from outside.
  - Do not weld anything to the conservator vessel if Air cell bag is inside.
  - Do not smoke near the transformer.
  - Do not use fibrous material for cleaning as it can deteriorate the oil when mixed with it.
  - Do not energise without thorough investigation of the transformer whenever any alarm of protection has operated.
  - Do not re-energise the transformer unless the Buchholz gas is analysed.
  - Do not re-energise the transformer without conducting all pre-commissioning checks. The results must be compared with factory test results.
  - Do not handle the off circuit tap switch when the transformer is energised.
  - Do not energise the transformer unless the off circuit tap switch handle is in locked position.
  - Do not leave off circuit tap switch handle unlocked.
  - Do not use low capacity lifting jacks / slings on transformer for jacking / slinging.
  - Do not change the setting of WTI and OTI alarm and trip frequently. Setting should be done as per manufacturer's instructions.
  - Do not leave any connection loose.
  - Do not meddle with the protection circuits.
  - Do not leave marshalling box doors open, they must be locked.
  - Do not switch off the heater in marshalling box except to be periodically cleaned.
  - Do not allow unauthorised entry near the transformer.
  - Do not close any valve in pump circuit for taking stand by pump and motor into circuit.
  - Do not allow water pressure to exceed the oil pressure in oil to water heat exchangers.
  - Do not mix transformer oils of different make/ base, unless oil is new and conforms fully to IS: 335.
  - Do not continue with pink (wet) silica gel, this should immediately be changed or reactivated.

- Do not store transformer in gas filled condition for more than three months after reaching site. If storage is required for longer duration, the main body should be filled up with oil.
- Do not leave tertiary terminals unprotected outside the tank.
- Do not allow WTI / OTI temperature to exceed 70°C during dry out of transformer and filter machine temperature beyond 75°C
- Do not parallel transformers, which do not fulfil the conditions for paralleling.
- Do not over load the transformers beyond limit specified in IS: 6600.
- Do not leave secondary terminals of any CT open.
- Do not measure insulation resistance by using megger when the transformer is under vacuum.
- Do not stand on any vessel, which is under vacuum.

- **TROUBLE SHOOTING**

Following table shows some of the symptoms, possible causes and remedies in case of abnormal situations: –

ABNORMAL OPERATING CONDITIONS

TROUBLE	CAUSE	REMEDY
High Winding/ Oil Temperature	Over voltage	Change the circuit voltage or transformer connections to avoid over excitation.
	Over current	If possible, reduce load. Heating can be reduced by improving power factor of load. Check parallel circuits for circulating currents, which may be caused by improper ratios or impedances.
	High ambient temperature	Either improve ventilation or relocate transformer in lower ambient temperature.
	Insufficient cooling	If unit is artificially cooled, make sure cooling is adequate.
	Low oil level	Top up oil to proper level.
	Deterioration/ Sludge formation of oil.	Use filter press to wash off core and coils. Filter oil to remove sludge.
	Short circuited core	Test for exciting current and no load loss. If high inspect core and repair. See Electrical Troubles, below.
Electrical Troubles/ Winding Failure	Lightning, short circuit, Overload Oil of low dielectric strength.	Usually, when a transformer winding fails, the transformer is automatically disconnected from the circuit by the circuit breaker.

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7) OPERATION

- After the inspection and pre-commissioning tests are successfully completed the transformer can be energised at no load.
- Oil soaking/ settling duration of 2 days for transformers up to 245 kV class and 3 days for 400 kV and above class are recommended after completion of hot oil circulation and before energising.
- Excessive vibration if any on any part of the transformer shall be located and rectified.
- Transformer shall be observed for any abnormality.
- If any gas is collected inside the Buchholz relay, it shall be analysed for its combustibility. If gas is not combustible, it indicates air trapped inside the transformer.
- All instruments should be checked for any abnormal indication.
- Check winding temperature and oil temperature readings at least once in every shift.
- Check and confirm that tap position indicators is same in local and remote indicators.
- Check and confirm that none of the alarms are indicated.
- Ensure that cooler power supply isolator is ON.
- Ensure that cooler control is in AUTO.
- Ensure that pumps and fans are running smoothly as temperature dictates. If the temperature is below the ON setting neither the pump nor fan should be running.
- After watching the operation of the transformer at no load for 24 hours and confirming that everything is normal, the transformer shall be taken on load.
- Observe the rise in temperature of oil and winding temperature indicators.
- While temperature is rising, confirm that fans and pumps are switched on automatically at the preset temperatures.
- While temperature is falling, observe that the pumps and fans are switched off at preset temperature.

a) ROUTINE / PERIODIC INSPECTION SCHEDULE FOR POWER TRANSFORMER

Sr. No.	Items to be inspected	Frequency
1	Load current	Hourly
2	Terminal Voltage	Hourly
3	Ambient Temperature	Hourly
4	Winding Temperature	Hourly
5	Oil Temperature	Hourly
6	Tap position	Daily
7	Air cell conservator	Daily
8	Oil level in Conservator	Daily
9	Oil level in Bushings	Daily
10	Oil level in OLTC Conservator	Daily
11	Oil level in breather cup	Daily
12	Connections	Monthly
13	Dust deposits & physical damages to bushings	Monthly
14	Air passage & colour of silica gel in breather	Quarterly
15	Cable boxes, Gasket joints, gauges etc.	Quarterly
16	Dielectric strength of transformer oil	Half yearly
17	Moisture content of transformer oil	Half yearly
18	Dissolved gas analysis of transformer oil	Half yearly
19	Resistivity of transformer oil	Half yearly
20	Insulation resistance of windings	Yearly
21	Tan delta & Capacitance of condenser bushings	Yearly
22	Operation of relays and their circuit	Yearly
23	Surface paint	2 ~ 3 Years**

Note:

** *Duration of surface repainting depends on the level of pollution prevailing at site. If pollution level is high, a frequent repainting schedule may have to be worked out.*

- *Lifting of core and windings are not recommended as a routine inspection.*
- *Core and coils are to be inspected only if such an inspection is warranted by test results of dissolved gas analysis, any abnormality in performance or for suspected internal damages due to external short circuit.*

b) MAINTENANCE SCHEDULE

Preventive Maintenance Procedures	**Periodicity**			
	Months			**Scheduled outage**
	3	6	12	
Replacement / Regeneration of Silica gel Breather	□			
Dissolved Gas Analysis		□		
Oil Sampling		□		
Buchholz Relay Functional Tests		□		
Tan Delta & Capacitance Measurement of Condenser Bushings			□	
OTI/ WTI Tests			□	
Tap changer operation			□	
Insulation Resistance of Windings			□	
Oil Filtration				□
Surface Painting				□

C) OIL SAMPLING

- Oil sample should be tested for the following and results recorded:-

(i) ELECTRIC STRENGTH

- If the dielectric strength of oil in transformer is less than 55 kV at 2.5 mm gap, the oil must be filtered to improve the characteristics.
- For line end OLTC diverter chamber, oil filtration is recommended when the BDV is ≤ 40 kV at 2.5 mm gap.
- For neutral end OLTC diverter chamber, oil filtration is recommended when the BDV is less than ≤ 30 kV at 2.5 mm gap.

(ii) MOISTURE CONTENT

- For transformers of 400 kV and above class, if the moisture content is found to have increased beyond 20 ppm oil should be filtered.
- For transformers of voltage class up to 245 kV, if the moisture content is found to have increased beyond 25 ppm oil should be filtered.

(iii) ACIDITY

- It the acidity is increased beyond 0.5 mg KOH/g, than the oil needs filtration.
- After draining the oil completely from the transformer, core, winding, insulation and interior of tank should be washed by hot oil jet. The oil being used for washing of internal body also must be drained completely.
- Refilling of oil in transformer should be done under vacuum.

(iv) SAMPLING PROCEDURE

- Special care in oil sampling is required for Delta connected transformer and autotransformers.

(V) TOOLS REQUIRED

- Spanner set
- Thermometer
- Steel sampling bottles with polyethylene cone caps.
- Silicon rubber tubing 10 mm bore - 1 m long.
- Clean synthetic sponge.
- Polyethylene sheet - 1 m square
- Clean cloths

- Self adhesive labels

(vi) PROCEDURE

- The sampling bottles shall be labelled and marked with information like source of sample, date and time & sample temperature.
- Sample bottle shall not be opened before it is needed for testing.
- Sampling point should be cleaned by using sponge.
- Blanking plate of sampling valve shall be removed by using spanner.
- Clean the silicon rubber tubing thoroughly and fit to sampling point nipple.
- Rinse the bottle in oil stream and reduce the rate of oil flow to 1 litre/minute.
- Put the end of rubber tubing to sampling bottle and fill the bottle from bottom.
- No air bubble shall be introduced into the bottle.
- The bottle is allowed to overflow before it is closed.
- Measure and record the temperature of oil sample as soon as it is taken.
- Put back and tighten the blanking plate.
- Remove all tools, excess oil container and oil sample from the area.
- Arrange for testing oil sample at laboratory.

d) WINDING TEMPERATURE INDICATOR TESTS

(i) TOOLS AND MATERIALS

- Hot oil bath (with heating facility)
- Secondary injection test set
- Multimeter
- Clinical thermometer
- Keys of marshalling box.

(ii) PROCEDURES

- The purpose of this check is to confirm that the winding temperatures Indicators are functioning accurately.
- The transformer shall be isolated and earthed.
- Rotate the indicator pointers slowly to the alarm set value and confirm from the control room that the alarm signal has been received.
- Rotate the pointer still further and confirm from the control room that trip signal is received.

(iii) CALIBRATION

- Remove the thermal sensing bulbs from the transformer and insert it into the hot oil bath.
- Check the winding temperature readings up and down the scale at intervals of 5 °C.
- Confirm from control room that remote temperature readings are tallying with the local readings.
- Replace the sensing element into the transformer pocket.

For any adjustment, see the manufacturer's catalogue.

(iv) SECONDARY INJECTION TESTS

1) ONAN RATING

- Set the cooler supply isolator of OFF position.
- Connect the secondary injection test set across the heater coil terminals.
- Inject current and check the resultant gradient for ONAN rating.

2) OFAF RATING

- In order to carry out these tests the pump must be running.
- Set the cooler isolator to ON position.
- Set the cooler switch to fans and pumps.
- Check and confirm that the pump is running.
- Inject current in the heater coil and check the gradient for OFAF rating.
- Disconnect.
- Set the cooler control switch to AUTO.

e) BUCHHOLZ RELAY FUNCTIONAL TEST

(i) Tools and Materials Required.

- Multimeter
- Nitrogen cylinder with regulator and pressure gauge or air supply (4 kg/cm²)
- Bucket
- 10 mm polythene tube, 10 meters.

(ii) PROCEDURE

- The purpose of this test is to ensure correct operation of Buchholz relay.
- Transformer shall be isolated and earthed.
- Connect nitrogen cylinder to the top petcock of Buchholz relay.
- Open the other petcock.
- Allow gas to enter the relay.

- Check and confirm from control room that alarm signal is received.
- Check continuity of alarm contact by using multimeter.
- Close petcock on gas supply side and release all gases trapped in relay casing.
- Increase the gas pressure to approx. 2 kg/cm² (30 psi)
- Open the test petcock and allow full surge of gas to enter the relay casing.
- Check and confirm from control room that trip signal has been received.
- Check continuity of trip contacts by using multimeter.
- Close Buchholz relay test cocks.
- If relay has not operated, increase gas pressure and repeat the test.
- If the relay is found faculty replace it with a new one.
- Open conservator shut off valve and release all gases trapped.

f) TAPCHANGER OPERATION

- Regular inspection of tap changing equipment is not required because mechanical operation of tap changer does not involve significant contact wear.
- It is sufficient to operate the tap changer through the whole range of tap selector positions twice a year.
- The purpose of this check is to ensure correct mechanical operation of tap changer.
- Transformer shall be isolated and earthed.
- Note the tap position.
- Operate the tap changer through operating handle through entire range of tap positions.
- Return to the original tap position.
- Set the local selector switch to LOCAL.
- Press RAISE button and release. Check and confirm the tap position indication has changed and that limit switch stops the tap changing at preset tap.
- Repeat.
- Press the LOWER button and release. Check and confirm that limit switch has operated and tap position indication has changed.
- Repeat till the tap position has returned to the original value.
- Set the local selector switch to REMOTE.

g) OIL FILTRATION

- Purpose of this maintenance is to improve the unsatisfactory condition of oil found during sampling.
- Transformer shall be isolated and earthed.

(i) TOOLS AND MATERIALS

- Oil conditioning plant (Filter Machine)
- 50 mm flexible hoses of sufficient length for oil inlet and outlet.
- Hose adapters to match the flanges of top and bottom filter valves.
- Cleaning cloths

(ii) PROCEDURE

- Remove the blanking plate from filter valves and connect the oil inlet hose to top filter valve and oil outlet hose to the bottom filter valve.
- Open the filter valves and start circulation of hot oil. Oil temperature shall be 55°C to 70°C.
- Circulate the oil for 4 full passes.
- Re sample and arrange to test.
- Continue until oil condition is acceptable.

(iii) CORRECTIVE MAINTENANCE

- All flange gaskets must be renewed wherever joints are dismantled.
- Cleanliness of gasket surfaces and correct compression (40 % ~ 50% approx.) of gasket must be ensured during reassembling.

h) REMOVING AND REFIXING OF PUMPS

(i) TOOLS AND MATERIALS

- Jib crane or chain pulley block to handle the weight of pumps.
- Oil drip tray
- Blanking plates
- New gaskets.

(ii) PROCEDURE

- Transformer is isolated and earthed.
- Close the isolating valves on either side of pump
- Disconnect the motor supply wires
- Remove the drain plug of the pump and drain oil from the pump.
- Remove the clamping bolts and remove the pump
- Blank off the isolating valve.
- For re-fixing the pump, remove the blanking plates.
- Fix new gaskets.

- Replace and tighten the clamping bolts.
- Open the isolating valves on cooler side.
- Open air release plug and close when oil starts flowing out.
- Open the isolating valve on transformer tank side.

i) REMOVING AND RE FITTING RADIATOR

(i) TOOLS AND MATERIALS

- Jib crane to handle the weight of radiator.
- Oil container (capacity approx. 1000 litres)
- Oil drain hose 50 mm bore
- Hose adapter to match flanges of fitter valve.
- Oil filter machine
- New gaskets.

(ii) PROCEDURE

- Transformer shall be isolated and earthed.
- Set the cooler supply isolator of OFF.
- Close the inlet and outlet valves if radiator is mounted on a separate cooler tank.
- Close the top and bottom isolating valves of radiator.
- Open the top air release plug.
- Remove the bottom drain plug and drain the oil to oil container under gravity.
- Sling the radiator with jib crane.
- Remove the radiator clamping bolts.
- Remove radiator.
- Blank off the radiator and header openings.
- Close the air release and drain plugs.
- For Re fitting the Radiator.
- Remove the blanking plates.
- Fix new gaskets.
- Assemble the radiator and tighten the clamping bolts.
- Open the top header air release plug.
- Open the bottom radiator isolating valve.
- If the radiator is on a separate cooler bank, oil shall be filled into the radiator bank through the bottom header valve by using the filter machine. If the radiator is tank mounted, the oil from the oil tank should be pumped into the tank by using the filter machine.

- Close the air release plug on top as soon as oil starts flowing through the air release plug.
- Shut down the oil filter machine
- Open top header isolating valve.
- In case of separate cooler banks, air should be released through the top common header air release plugs.

j) REMOVING AND RE FITTING FAN & MOTOR

(i) TOOLS AND MATERIALS

- Forklift truck to take weight of fan and motor assembly.

(ii) PROCEDURE

- The transformer is to be isolated and earthed.
- Set cooler supply isolator to OFF and lock the marshalling box.
- Disconnect the fan motor supply wires.
- Support the weight of fan and motor assembly by using fork lift truck.
- Unbolt fan and motor form fan mounting frame.
- Lower the fan from the fan-mounting frame.

(iii) REFITTING FAN AND MOTOR

- Assemble the fan and motor in position and tighten clamping bolts.
- Re connect the power supply wires.
- Unlock marshalling box and set cooler supply isolator to ON.

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8) SHORTAGE & FAILURE REPORT

In case of shortage or damage, customer should immediately report (within 15 days) this to transport representative and to the nearest branch office of the TMC Transformers Pvt. Ltd., giving following information.

(i) Maker's reference number of the transformer.

(ii) Serial number of the transformer.

(iii) Nature of damage and the item number and description of the damage components should be furnished. In the case of failure apart from giving the maker's reference number and the serial number of the transformer, the customer should give the following information also.

1. Flag indication, if and the events leading to nature.
2. Insulation resistance of HV/E, LV/E and HV/LV & corresponding temperature in ^{0}C.
3. Insulation resistance at the time of last filtration & corresponding temperature in ^{0}C.
4. Oil breakdown voltage.
5. Colour of gas in Buchholz relay.

The above information is necessary to expedite the matter at our end. Customer may also contact the customer service department at our works at the telephone numbers given on the front cover of this manual.

APPENDIX – A ERECTION CHECK LIST

TRANSFORMER ERECTION CHECK LIST

This checklist is intended for use at site by Site Engineers. It outlines the minimum on site checks expected to be carried out during the erection activity.

CUSTOMER **: .....**

EQUIPMENT DETAILS **: .....**

SITE **: .....**

SR. NO.	CHECK POINT	STATUS		REMARKS
		O.K.	NOT O.K.	
1	**AVAILABILITY OF DOCUMENTATION**			
	Erection drawings including OGA			
	Erection / Maintenance Manual			
	Transport packing list			
2	**RECEIPT OF TRANSFORMER**			
	Externally inspected damage (if any)			
	Gas pressure on receipt (Where applicable)			
	Oil level (in case of oil filled transformer)			
	Unit correctly positioned			
3	**RECEIPT OF ACCESSORIES**			
	All materials stored correctly			
	Packing Cases inspected, damage if any			
	Marshalling box inspected, damage if any			
	Control panels (RTCC)inspected damage if any			
	Materials received corresponded to Advise note			
	Any shortages / wrong supply			
	Materials comply with shipping specification			
	Remark (if any)			

SR. NO.	CHECK POINT	STATUS		REMARKS
		O.K.	NOT O.K.	
4	**ERECTION**			
	Transport rollers mounted			
	Conservator mounted			
	Buchholz relay and oil surge relay mounted (arrow marked should be towards conservator)			
	Breather mounted and duly charged			
	HV Bushings mounted			
	LV Bushing mounted			
	Tertiary Bushing mounted (if applicable)			
	HV neutral Bushing mounted			
	LV Neutral Bushing mounted			
	Bushing installed at correct angles			
	Diaphragm checked			
	MOLG mounted			
	Radiator mounted			
	Fans mounted			
	Pressure Relief valves mounted			
	Alignment of all pipe work			
	OLTC Conservator mounted			
	Heat Exchangers assembled with pipe work			
	Topping up of transformer oil			
	Leakage observed after 24 hrs.(if any)			
	Rating Diagram and identification plate fitted			
	Control panel (RTCC) aligned			
	Control panel (OLTC) aligned			

SR. NO.	CHECK POINT	STATUS		REMARKS
		O.K.	NOT O.K.	
5	**OIL FILLING**			
	All bushing oil level			
	Tap changer selector oil level			
	Diverter switch oil level			
	Auxiliary unit oil level			
	Radiator, Headers oil filled			
	Transformer / OLTC Conservator oil tight			
	Complete transformer oil tight			
	All air release plug vented			
	Valves in service position			
	All drain / filter valves blanked			
6	**MULTICORE CABLE**			
	All tray work adequately secured			
	All cables adequately tied/clipped back to tray			
	Cables glaned correctly			
7	**BREATHERS**			
	Transformer silica gel breather satisfactory			
	Tap changer silica gel breather satisfactory			
	Dry breather correctly installed			
8	**FANS**			
	Fans rotate freely & quickly			
	Pumps installed for correct flow			
	Flow indication visible			
9	**CONTROL PANELS**			
	Cable termination & Glanning			
10	Cleaning and touch up of painting			

APPENDIX -B PRE-COMMISSIONING CHECKS

Customer: _____ Site: _____

TRANSFORMER DETAILS:	Rating:	Oil Qty:
	Voltage:	Mass of oil:
	Year of Manf.:	Wight of C&W:
	Sr. No.:	Impedance:
	Vector Group:	TR Tag #:
OLTC/OCTC DETAILS:	Make:	YOM:
	Type:	Sr. No.:
	Tap Position:	

GENERAL CHECKS:

SR. NO.	CHECK POINTS	STATUS		REMARKS
		O.K.	NOT O.K.	
1	Direction & mounting angle of O.S.R. & Buchholz relay			
2	Dryness of silica gel, seal removal & oil level in bottom cup			
3	Oil level in Main conservator.			
4	Oil level in OLTC conservator.			
5	Oil filled in OTI / WTI pockets.			
6	Earthing of Main tank, cooler bank, neutral, fans, pumps, etc			
7	Absence of oil seepages / leakages.			
8	Bushing -their oil levels & test cap covering.			
9	Explosion vent & rupture pin setting.			
10	Touch up painting & washing.			
11	Overall clearances.			
12	Atmoseal commissioned (top gauge glass to show full oil)			
13	Sagging of radiator / pipes			
14	Tightness of bushing top seal			
15	Distortion in expansion bellows / removal of transit support			

A. MARSHALLING BOX (Sl. No. & Rating: _____)

SR. NO.	CHECK POINTS	STATUS		REMARKS
		O.K.	NOT O.K.	
1	**W.T.I. (Sl. No., Make & Model)**			
	a. Transit lock release.			
	b. Switch settings & operation.			
	c. Connections.			
	d. Ambient reading.			
	e. Heater shunt shorting link.			
	f. Matching with repeaters.			
	g. Power supply & current converter			
2	**O.T.I (Sl. No., Make & Model)**			
	a. Transit lock release			
	b. Switch setting & operation.			
	c. Connections.			
	d. Ambient reading.			
	e. Matching with repeaters.			
3	Space heater & Thermostat settings.			
4	Cabling, Glanding, Termination etc.			
5	Earthing & Touch up painting.			
6	Stand by supply change over operation			
7	Timer settings.			
8	Closure of openings & tidiness.			

B. FANS: (Model, RPM, KW / HP.) _____

SR. NO.	CHECK POINTS	STATUS		REMARKS
		O.K.	NOT O.K.	
1	Glanning & Earthing.			
2	Mounting & Terminal cover condition.			
3	Direction & Smoothness of operation :			
	a. Manual - Local.			
	b. Manual - Remote			
	c. Auto & Stand by operation			
4	Overload setting			
5	Starting current			
6	Running current			
7	Megger values			

C. O.L.T.C. (Sr. No. , Make & Type) _____

SR. NO.	CHECK POINTS	STATUS		REMARKS
		O.K	NOT O.K.	
1	Alignment of all shafts & Drive Mechanism			
2	Oil fill in gear box (Where reqd.)			
3	Mechanical end limits of D.M.			
4	Manual operation.			
5	Local electrical operation.			
6	Electrical end limit operation.			
7	Remote electrical operation.			
8	Tightness of external shaft coupling			
9	Bending of lock washer.			
10	Fitment of window & shaft covers.			
11	Cabling, Termination, Glanning etc.			
12	Space heater & thermostat setting.			

SR. NO.	CHECK POINTS	STATUS		REMARKS
		O.K	NOT O.K.	
13	Continuity check during transition by voltage application.			
14	Earthing.			
15	TPI counter reading			
16	CCU for TPI			

D. R.T.C.C.: (Sl. No. & Rating): _____

1	Installation & Earthing.			
2	Cabling, Glanning, Termination etc.			
3	Setting of Timers.			
4	Functioning of Indication Lamps.			
5	Functioning of Hooter / Buzzers.			
6	Annunciation / Relay Checks:			
	a.			
	b.			
	c.			
	d.			
	e.			
7	Tap position indicator.			
8	W.T.I. Repeater.			
9	O.T.I. Repeater.			
10	O.L.T.C. Operations :			
	a. Individual :			
	b. As Master :			
	c. As Follower :			
11	Emergency Trip.			
12	Out of step & MP Timer operation.			
13	Operation of A.V.R. & L.D.C.			

E. Operation of Pumps, NRV, Flow Indicators:

SR. NO.	CHECK POINTS	STATUS		REMARKS
		OK	NOT OK	
1	Direction of pump operation.			
2	Manual operation.			
3	Auto operation.			
4	Stand by change over			
5	Non Return Valve operation.			
6	Overload setting			
7	Starting current			
8	Running current			
9	Stability of alarm & trip contacts of Buchholz relay during oil pump starting by manual / Auto mode			
10	Megger value (500 V / 1000 V Megger)			

APPENDIX -C TEST RESULTS

NOTE: Instruments provided by Customer will normally he used for the tests after ascertaining their operation in the applicable ranges.

1. **Voltage Ratio test:-** (Voltage applied on HV Side and **measured on LV Side – in Volts**)

	1U1V		**1V1W**		**1W1U**	
Tap No.	**2U2V**	**2V2W**	**2W2U**	**2U2N**	**2V2N**	**2W2N**
1						
2						
3						
4						
5						
6						
7						
8						
9						

2. **A) Magnetic Balance test:-** Tap No.: (* - All values are in volts)

1U1V	**1V1W**	**1W1U**	**2U2V**	**2V2W**	**2W2U**	**2U2N**	**2V2N**	**2W2N**

3. **Magnetizing Current test:-** on HV Side (Voltage applied on HV Side, and current **measured on HV Side – in Mille Ampere**)

	1U1V	**1V1W**	**1W1U**
Tap No.	**1U-ph**	**1V-ph**	**1W-ph**
1			
2			
3			
4			
5			
6			
7			
8			
9			

4. **Megger/PI Test:-** (at temp.= °C)

Instrument Details: Make:			Sr. No: Capacity:		
I.R. Value	**Voltage**	**15 sec**	**60 sec**	**600 sec**	**PI** (If applicable)
HV-Earth	5000				
HV-LV	2500				
LV-Earth	1000				

5. **Vector Group Test:-** (Shorted 1U & 2U terminal and Voltage applied on HV Side i.e. to 1U1V – 1V1W – 1W1U):- (Before any activity done)

1U1V=		**Conditions Required:**		
1V1W=		**1W2V>1W2W**	**1U2N+1V2N=1U1V**	
1W1U=		**1V2V=1V2W**		
Readings				
1V2V=		**1V2W=**	**1U2N =**	
1W2V=		**1W2W=**	**1V2N =**	
Remarks:-	From above it is confirmed that vector group is			

6. **Oil BDV Test:-** measured in Kilo Volt (with 2.5 mm gap & average of 05-strokes)

	Before Filtration		**After Filtration**	
Main Tank (Bottom)		KV		KV
OLTC		KV		KV

Tested By:	**Customer Sign:**	

APPENDIX –D CHECKS BEFORE ENERGIZATION

To be carried out after transformer is connected to lines & before energization

SR. NO.	CHECK POINTS		STATUS		REMARKS
			O.K	NOT O.K.	
1	Clearances in air (refer O.G.A.)				
2	Arcing horn gap set (refer O.G.A.)				
3	Tightness of bushing lugs, cable / line connections, terminals, etc.				
4	Simulation of Alarm & Trip circuits (verify breaker / Master trip operation by initiating operating contacts of)				
	a.	Buchholz relay			
	b.	Winding temperature indicator			
	c.	Oil temperature indicator			
	d	Oil surge relay			
	e.	Pressure relief device / vent switch			
	f.	M.O.L.G.			
	g.	Oil / Water flow indicators / D.P.G.			
	h.	Sudden pressure relay			
5	Air Release from:				
	a.	Bushings			
	b.	Radiators, headers			
	c.	Buchholz relay			
	d.	O.L.T.C. cover / head			
	e.	Main tank cover / Thermosyphon			
	f.	Disconnecting chamber			

Transformer is successfully charged on dtd. _____ at _____ Hrs. On tap position no._____ on no load condition & load is taken on dtd. _____ at _____ Hrs. No abnormality found during charging and loading condition. Transformer put on _____ Amp. / MVA _____ load on _____ at _____ Hrs and is operating satisfactorily.

Signature: ---------- ----------

Name: ---------- ----------

(FOR TMC) **(FOR CUSTOMER)**

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