Operation Erection and Maintenance Manual

Oil Filled Transformers

General Engineering Works

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WELCOME

Dear Customer,

This owner's manual will provide you with good understanding of the operation and basic maintenance of the Transformer, to ensure a long trouble free performance, please give due care and maintenance to your transformer as recommended in this Owner's Manual. If you have any queries, suggestions to be incorporated regarding the operation or maintenance of your transformer, please consult your **M/s. GEW Service Center** who will be too happy to help you.

We are,
At your service.

General Engineering Works
services@geworks.co.in
www.geworks.co.in

WARRANTY

a) The Warranty cover is limited to defective material, faulty design or poor workmanship.

b) However the warranty shall not apply to defects resulting from:

(i) willful damage or negligence by the Purchaser,

(ii) normal wear and tear,

(iii) wrong installation and /or maintenance by Purchaser or a third party,

(iv) Storage of Equipment post-delivery for a period 90 days without installation and Commissioning.

(v) misuse or abuse of Equipment by the Purchaser,

(vi) modifications or alterations made by Purchaser or a third party without supplier's written consent,

(vii) failure of Purchaser to maintain environmental conditions in accordance with Supplier's instructions, including, but not limited to, adequate electrical power, temperature and humidity control,

(viii) operation beyond its rating and specification,

(ix) customized Equipment manufactured by third parties for incorporation into Equipment and for resale to Purchaser except that Purchaser shall be entitled to the benefit of any warranty or guarantee given by such third party manufacturers, and

(x) causes beyond supplier's reasonable control

(xi) Damage to equipment post transfer of risk i.e. after the Equipment is loaded in the transport in case of ex-works delivery of Equipment.

The warranty shall not cover the usefulness or fitness for purpose of the Equipment. Only the Purchaser shall be responsible for its intentions and usage of the Equipment. The Purchaser's sole and exclusive remedy shall be Supplier's obligation to repair or replace as set forth above in this warranty. For products not manufactured by the Supplier itself, Supplier shall only be liable to the extent of the warranty given to Supplier by its own suppliers and within the above time limit.

c) The Warranty shall be valid as per contract OR 18 months from the date of ex-works dispatch or 12 months from the date of commissioning of Equipment, whichever expires earlier.

d) During warranty period, Supplier's liability shall be limited solely to repair or replacement of the defective part(s) at its option. The decision on the method of repair and extent of replacement rest solely with the Supplier. Parts and components, which are repaired or replaced during such period, are warranted for the original warranty period.

e) The Supplier shall decide whether repair shall be carried out at the site of the Equipment or a defective part shall be returned to Supplier for replacement, or any other solution. No product will be accepted for repair or replacement without the authorization of and in accordance with instructions of the Supplier. Removal and reinstallation expenses as well

as transportation expenses associated with a returning of Equipment to Supplier shall be borne by the Purchaser. In case of any repair/replacement of defects to be undertaken at site, purchaser shall provide necessary assistances required for such rectification at site at free of cost.

f) After Supplier repairs such Equipment or acquires a replacement Equipment, the Supplier shall pay the cost of transportation of the repaired or replaced Equipment. If Supplier determines that the returned Equipment was not defective, Purchaser shall pay Supplier's costs of handling, inspecting, testing and transportation and, if applicable, travel and related expenses. In repairing or replacing any Equipment or part of Equipment under this warranty, Supplier may use either new, remanufactured, reconditioned, refurbished or functionally equivalent products or parts; provided, however, that such repair or replacement will not impact upon the function of the Equipment under normal and proper use, as provided in the specifications. The replaced Equipment or parts shall become property of the Supplier. All replaced parts must be returned to Supplier within one month of their replacement, in default of which their value will be invoiced.

g) For any claim of warranty, the Purchaser shall have to promptly notify the Supplier within 10 days after discovery of any defect, or within 10 days after the date that such defect should have been discovered, in writing of such defect or non-conformance. The Supplier shall analyze such notice and intimate, if any, further information is required. The Supplier may inform remedial measures to be taken by Purchaser within a reasonable period of time.

h) The Purchaser shall at its own expense arrange for any dismantling and reassembly of other equipment than the Equipment delivered by the Supplier, to the extent that this is necessary to remedy the defect.

i) In case Transformers are erected, or commissioned without the supervision of Supplier OR not as per the instructions given in Operation and Maintenance manual provided, the Supplier shall not stand liable for the warranty obligations and this warranty automatically stands Invalid.

j) For warranties extending beyond (period even within PO contract warranty but beyond 12/18Month), all the yearly maintenance results (eg. Oil testing, Insulation resistance etc) must be shared with GEW.



The warranty will be null & void in case installation, commissioning and maintenance is not done in line with the recommendation of this manual

Before charging the transformer the customers are advised to share the pre commissioning test results with the GEW and get the charging clearance. Charging without consent of GEW will render the warranty null & void.

1. GENERAL

a) **M/s. 'GEW'** transformers are designed manufactured and tested to ensure the ease of installation, reliability with minimum attention.

b) The scope of this manual is to make the user aware of how the transformer should be installed, commissioned and maintained.

c) When installed and commissioning with care, transformers usually require less maintenance than any other electrical apparatus.

d) In addition to the instructions given in this manual, reference should be made to following standards:

SPECIFICATION NO.	TITLE
I.S. 2026 Parts I to V	Power Transformers
I.S. 3639	Fittings & Accessories for Transformers.
I.S. 335	New Insulation Oil for Transformer Switch gears.
IEC 62770	Fluids for electro technical applications – Unused natural esters for transformers and similar electrical equipment
IEC 61099	Specifications for Unused Synthetic organic esters for electrical purposes
IEC 61203	Synthetic organic esters for electrical purposes – Guide for maintenance of transformer esters in equipment
IEEE C57.147	Guide for Acceptance and Maintenance of Natural Ester fluids in transformers
I.S. 10028-Parts I to III	Code of Practice for Selection, Installation & Maintenance of Transformers.
I.S. 1866	Code of Practice for Maintenance of Insulation Oil.
I.S. 1886	Code of Practice for Maintenance and supervision of mineral insulating oil in equipments.
I.S. 2099	Bushings for A/C voltage above 1000 v
I.S. 3347(Part-1 to 8)	Dimensions of Porcelain Transformers/ Bushings
I.S. 6792	- Method of determination of Electric strength of insulation oil
I.S. 8468	On-Load Tap Changers
I.S. 8478	- On-Load Tap Changer Application Guide
I.S. 1646	Code of Practice for fire safety of Buildings (General) Electrical Installation
I.S. 3043	Code of Practice for Earthing
I.S. 2705 (Part-1 to 4)	Current Transformers
I.S. 3637	Specification for Gas-operated Relay.
I.S. 6600	Guide for loading of oil immersed transformers
I.S. 6272	Industrial Cooling Fans

2. PACKING AND SHIPPING

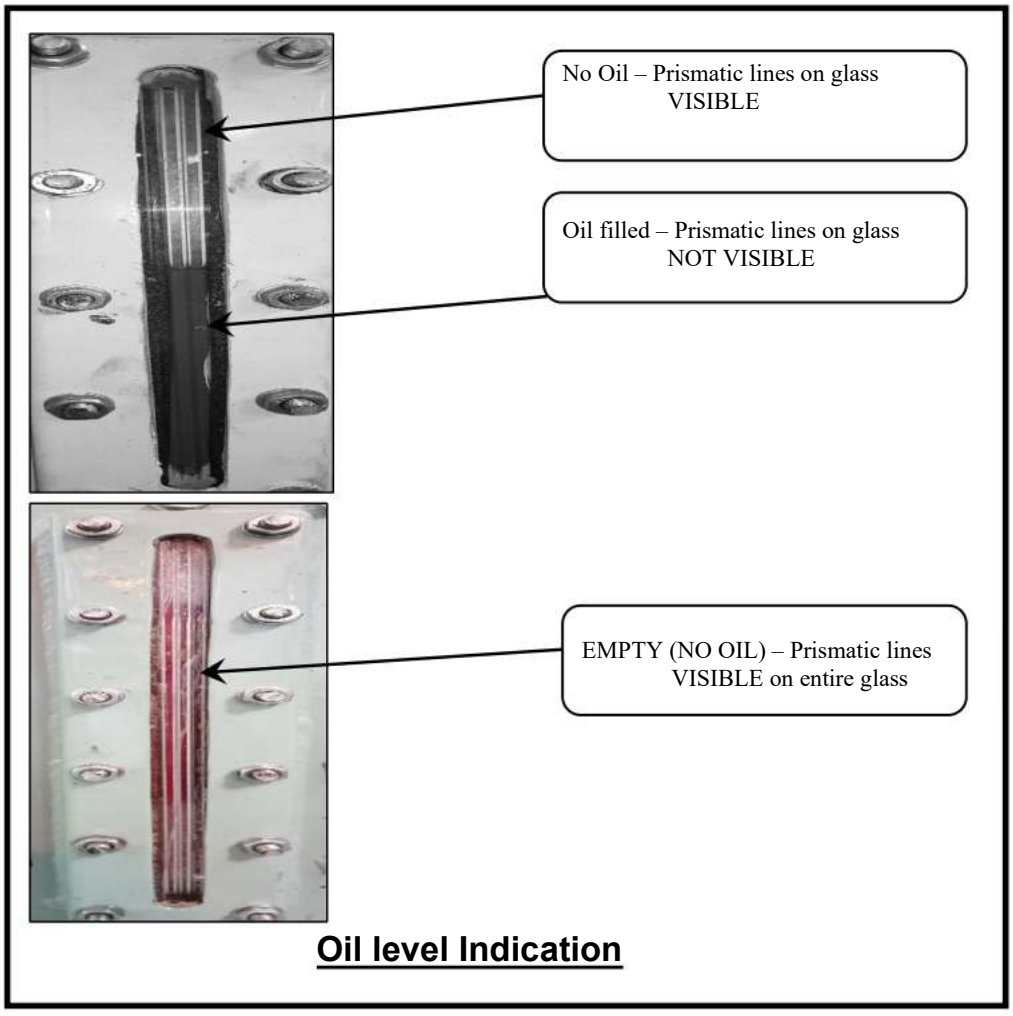
Considering the transport dimensional and weight limitations, distance and risk / damage during transit, the transformers are dispatched in one of the following manners.

- ➢ Fully assembled (ready for erection, testing and commissioning)
- ➢ Main tank filled with oil, Accessories & fittings dismantled.
- ➢ All Parts dismantled for transport are packed either separately or in groups as per space availability. Each packing case / crate is given a number and referred in the packing slip along with description of its contents and quantity.

3. INSPECTION ON RECEIPT AT SITE

Request to follow below mentioned points while unloading/ receiving your transformer at site

1. Do not release the lorry without checking the oil level in main tank and OLTC for any pilferage or leakage during transportation. Oil can be checked form the oil level gauge provided on the side wall (near tank cover) on the main tank. For OLTC please open the air release plug and verify oil level.



Oil level Indication

2. Verify the quantity of all items received as mentioned in the packing list provided.

3. For any shortage or damage observed, please take a photograph (this is must), take signature of the lorry driver, and intimate to GEW on the same day. Any intimation regarding shortage or damage on later date might run the risk of non-entertainment.
4. In case of lorry number mismatch, do not release the lorry without getting confirmation from GEW. Any issues of shortage, damage etc. in such case may not be attended if lorry number change is not informed to GEW.

3.1 Reporting of Damages, Shortages, Wrong Supply, Pressure Drop and Leakage's

If any damages, shortages and leakage's are observed, then open delivery certificate from the carrier is to be obtained (for transit damages), for others enclosed attached format to be filled and reported to the firm within 15 days of receipt to enable the firm to lodge Insurance Claim if applicable and to attend the complaint.

Please ensure to fill the checklist below at the time of receipt of transformer.

Transformer Sr. No :	
Rating :	Voltage Ratio :
Date Of Dispatch :	Date Of Receipt:
Name of Transporter :	Site Location :

Checks to be Performed on Receipt of Transformer			
Sr. no	**Check**	**Condition**	
1	Oil level in the Oil level gauge of transformer/ conservator	Oil **SEEN** Oil gauge Glass	Oil **NOT SEEN** Oil gauge Glass
2	Rollers received with main transformer	Received	Not Received
3	Condition of Valves	Not damaged	Damaged Qty……..
4	No of Packed cases as per documents	Matching	Not matching Shortage Qty……
5	Condition of Packed cases	Not damaged	Damaged
6	Magnetic Oil level gauge	Not damaged	Damaged
7	Marshalling box glass	Not damaged	Damaged
8	Oil level Indicator /Winding temperature Indicator	Not damaged	Damaged
9	Mounting hardware of cable boxes /bus duct	Available	Not Available
10	Radiators	Not damaged	Damaged

Note : Please tick (v) as applicable

Any other Details:

ITEM	CASE NO.	OBSERVATIONS	INITIALS / DATE

Signature With Seal

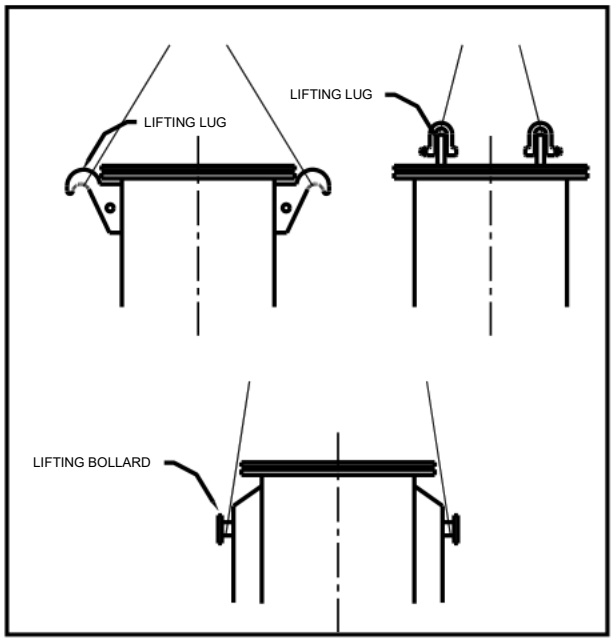
Note:

Please take photographs of all damages, oil level and report all damages and missing item immediately to General Engineering Works. No Claim shall be accepted at later stage on account of damages/shortages

4. UNLOADING and HANDLING

4.1 Main Tank:

➢ Different types of lifting arrangements as shown in the drawing below are provided on different transformers based on total weight, construction etc. Lifting arrangement for a particular transformer is shown in the Outline General Arrangement (OGA). Please use the shown arrangement ONLY. In case transformer is lifted using any other lifting arrangement/ method GEW will not be responsible for loss or damage to equipment, person or property.



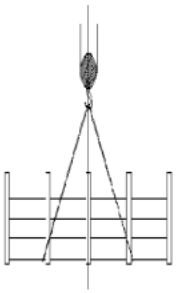
➢ The transformer should be unloaded by means of crane or lifting device of sufficient Capacity (refer rating plate for details of weight).

➢ All lifting lugs should be used to avoid unbalance and uneven stress.

➢ While lifting, slings should not rest / touch any other parts of the transformer especially for bushings.

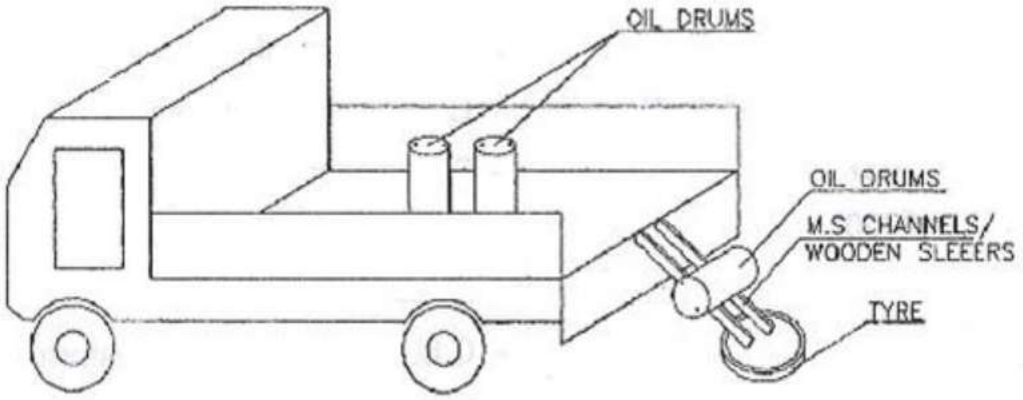
4.2 Accessories

➢ The cases / crates should be unloaded as shown in figure. (for Radiator refer Do-Don't figure in Clause 7.7)



➢ The cases should not be dropped down abruptly to avoid damages to the delicate instruments packed inside.

➢ The oil drums shall be unloaded as shown in figure or if suitable facilities are available for lifting/unloading of drums.



5. STORAGE

➢ On receipt of the Transformer at site, it is desirable to install and commission the transformer with minimum delay. In case, this is not possible, the silica gel breather should be fitted. The breather contains 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 turning pink.

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 above 60 KV (RMS). It is desirable to keep the transformer in a place where temperature variation is minimum or energized even at a low voltage so that the oil temperature is about 10° to 15° higher than the surrounding ambient temperature.

Even during temporary storage, it is recommended to mount rollers by jacking up the transformers to enable free flow of air underneath. If rollers are not mounted main tank should be kept over wooden/ M.S. support to avoid rusting.

The tap changer should be operated at six-monthly intervals, two or three cycles from one end of the range to the other are considered sufficient.

☑ **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. If they are not stored properly, they are likely to be damaged. The conservator pipe work and radiators are dispatched with blanking plates and these are to be stored with their blanking plates, in position.**

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

Heaters in the marshaling kiosks, OLTC Drive Mechanisms (DM), Remote Tap change Cubicle (RTCC) etc., should be kept energized to avoid condensation.

5.2 **Oil Drums:**

If oil received in drums is not likely to be used immediately, the drums should be stored in a covered space where temperature variation is minimum. If it is necessary to store the drums outside, adequate protection must be provided. Drums should not be stored standing on end but should be placed on their sides with the bung at 45 ° downwards. Such a way that air releasing & drain opening are under oil to avoid the water seepage. Refer figure.

☑ It is very important that drums are stored free from fire, water accumulation and explosion hazards. Refer below figure.

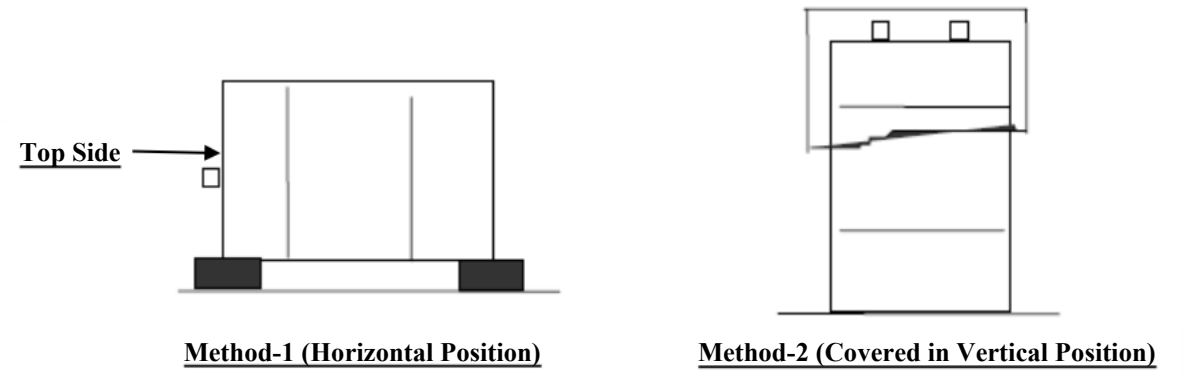


Figure: Outside Storage of Oil Drums

5.3 If the Erection & Commissioning is delayed beyond one year or so, repainting is recommended to avoid rusting.

5.4 In case of Ester oil transformer oil drums following points to be considered while storage.

- It is highly recommended to store the drums in dry location, out of direct sunlight (UV rays)
- Prolonged storage in low temperature at negative temperature will cause the viscosity of ester oil to significantly increase.
- If properly stored indoor in temperature within 10°C to 40°C and away from direct exposure to sunlight, unopened containers of ester oil have a shelf life of 10 years.,
- Once opened, precautions should be taken to avoid contact with moist air for prolonged periods because the liquid is hygroscopic and will absorb atmospheric moisture. If a partially emptied container is used for storage the head space should ideally be back-filled with dry nitrogen or dry air prior to resealing. Additionally, it is important to ensure the lid is properly sealed.

Caution: Special Care to be taken while handling of Ester Oil

6. FITTINGS & ACCESSORIES:

6.1 Rating & Terminal Marking Plate: (R & D Plate)

The transformer is supplied with rating and terminal marking plate made of non-corrosive metal. The plate contains information

- Standard
- Transformer type
- Vector group
- Rated power (KVA)
- Voltages rating
- Frequency
- Number of phases
- Tap positions
- Oil Quantity

- Transformer unit Sr. No.
- Year of manufacturing.
- maximum temperature rise of winding and top oil temperature
- Current transformers Details
- Dielectric Insulation levels

6.2 Tap Changing Arrangement:

6.2.1 off-Circuit Tap Changing Switch Mounted On Tank Cover:

In this case, the transformer is 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.

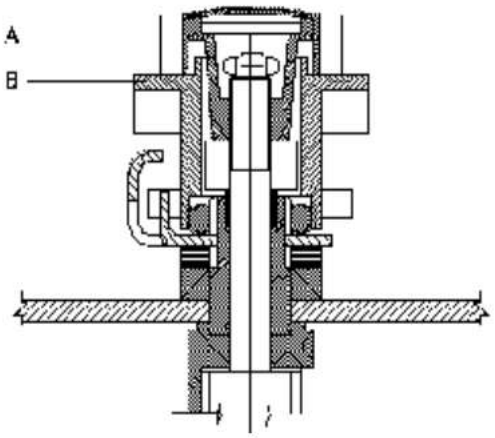
Caution: THE TRANSFORMER MUST BE ISOLATED FROM ALL THE LIVE LINES, BEFORE OPERATING THE SWITCH.

Operating the switch when transformer is energized, 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 sidewall, it is necessary that switch handle assembling be dismantled before untanking.

6.2.1.1 Tap Changing Procedure For Switch Handle Mounted On Tank Wall.

➢ Before operating the tap changer see the instructions given on the instruction plate fixed near the tap switch. (Refer the figure)



Linear Type Tap Switch

➢ Unscrew Locking Cap –A
➢ Pull and change Control Knob – B
➢ Screw Locking Cap -A
➢ Check for the tap position arrived at right place.

6.2.1.2 Tap Changing Procedure for Switch Handle Mounted On Tank side.

➢ Before operating the tap changer see instructions given on the hand wheel



Rotary Type Tap Switch

- ➢ Remove pad lock from positioner of handle.
- ➢ Pull the pin / knob of spring loaded positioner and rotate the wheel to the required tap number of the indicating disc and engage the pin in the locking hole.
- ➢ Put the pad lock to prevent inadvertent operation.

6.2.2 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 optional fittings.

For both off circuit and on load tap changer the tapings are normally located on high voltage winding.

For further details, please refer to the manual of OLTC and schematics.

6.3 Earthing Terminals:

The core laminations assembly is connected to core clamping frame, 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 earth.

6.4 Lifting Lugs:

Four lifting lugs of adequate capacity are provided on tank sides to lift fully assembled transformer filled with oil. (For cover mounted units refer OGA)

All lugs are designed for simultaneous use and must be used accordingly. Four lifting lugs are provided for untanking the core and windings of larger capacity transformers.

All heavy fittings are also provided with individuals lifting lugs.

6.5 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 plug/blanking plates to stop oil coming out.

Mainly two types of valves are provided.

- ➢ Wheel Valves.
- ➢ Butterfly Valves.

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

Generally, one isolating Valve is provided 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.

6.6 BUSHINGS:

6.6.1 Oil Communicating Type:

Transformer windings are connected to the external circuit through terminal bushings. The bushings are installed on the cover or, on sidewalls 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 and external conductors outside it.

The shape and size of the bushing depend on the voltage class, type of current, Electrical performance of these bushings conforms to I.S. 2099 & I.S. 7421. Dimensional details and associated parts generally conform to I.S. 3347 up to 36 KV Class. Assembly and dismantling of single piece type bushings is possible without disturbing the active part.

6.6.2 Cable Boxes (if Applicable):

Cable boxes are designed for receiving and protecting cable ends

Cable boxes for PVC or 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 terminal is also provided on these cable boxes for earthing the armoring of individual cables.

When Cable Boxes are provided with disconnecting chambers they permit removal of transformer for servicing without disturbing cable terminations.

(**Note:** Refer enclosed cable box drawing.)

6.6.3 Bus-duct trunking (if Applicable):

Some users prefer connections to load by means of bus duct. Bus duct is supplied by some other agency. However, we provide suitable flanges / trunking around transformer bushings for receiving the bus duct. The agency should manufacture the bus duct to suit this.

The level of the bus duct flanges from ground/rail level is indicated in the General Arrangement drawings of the transformer. The complete details of bus duct flange are furnished by us, giving complete dimensional details for the matching flanges, bolt spacing, bushing terminal details, etc. (Note: Refer enclosed Bus-duct drawing.)

6.7 Marshalling Box (M.B) / Terminal Junction Box (TJB)/Fan Control Cubical (FCC):

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 / trip / annunciation under abnormal conditions and if further required to disconnect transformer from mains. In order to facilitate connections of all such devices to the protective scheme, the cables from all such contacts are wired up to a weatherproof terminal box. This box called marshaling box, is also used for housing Oil Temperature Indicator (OTI) and Winding Temperature Indicator (WTI).

The Marshaling box is made of sheet metal and is provided with an observation glass for observing OTI & WTI.

It has a hinged door with locking facility to prevent unauthorized access. The capillaries from OTI & WTI come out from the bottom of the marshaling box through suitable gland plate thus preventing ingress of dust.

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

In case of transformers fitted with cooling fans the controls for them are provided in these same box.

6.8 Buchholz Relay:

Buchholz Relay is a very sensitive, gas and oil operated apparatus, which detects formation of gas or development of oil and gas surge inside the oil filled transformer. It is connected to protection circuits to give an early audible alarm of gas collection and to disconnect the transformer from supply in case of sever fault inside the transformer.

The basic function of the relay is to initiate an electrical signal in the protection circuit when:

- ➢ Gas is accumulated in the relay, as result of incipient fault.
- ➢ Surge of oil is developed on account of sudden generation of gas inside the transformer due to sever fault.
- ➢ Oil level in the relay is reduced below the minimum level.

6.8.1 Buchholz Relay operates in the following manner .

The relay comprises a housing containing two pivoted Bucks / Floats counter balanced by dead weights. Each bucket assembly carries a mercury switch. The relay is fitted in the oil connection between conservator and tank.

Due to gas collection, the oil level inside the relay drops and the upper bucket moves down. This tilts the mercury switch bringing fluid mercury in such a position so as to bridge the normally open (NO) contacts. Other probable reasons for dropping of oil level in the relay are:

- ➢ Leakage of oil from main tank, conservator or relay itself.
- ➢ Collection of air in the relay, which is trapped earlier in the tank and in the winding.

The lower bucket operates similar to upper bucket when level in the relay drops further. However, important function of this lower bucket/float is to disconnect transformer from circuit under sudden development of pressure inside the transformer due to severe internal fault. In such cases, gas generation is rapid and displaced oil surges through the relay impinging on the baffle plates causing lower bucket to tilt and close the Normally Open (NO) contacts of the mercury switch carried by it.

Upper bucket contacts (A) are usually connected to audible alarm ‘A’ circuit and lower bucket contacts (T) are connected to trip circuit.

The relay is mounted in position with associated piping and isolating valves at works. In larger transformers, the Buchholz relay assembly is dismantled and sent separately. When Test Lever is provided, it is sent in ‘Test’ position to prevent damage in transit. On receipt at site, check the relay for any damage to window glasses and mercury switches.

Mount the Buchholz Relay between conservator and transformer tank cover along with piping & valves without straining the pipeline. Isolating valve must be fully opened after mounting is completed. To ensure successful operation of the relay the pipe work in either side of the relay is set inclined to horizontal by $3\text{-}7^0$.

Caution: MOUNT RELAY SUCH THAT ARROW DIRECTION POINTS TOWARDS CONSERVATOR

After filling oil in the transformer, air trapped inside the relay is to be released through the valve/petcock provided on top of Buchholz relay. If a pipe extension from this valve is brought down for gas collection, it must be ensured that this valve is kept open and the pipe is full of oil. When gas is collected, oil from pipe will flow out first and then gas will come out.

6.9 Radiators:

The function of radiators is to limit the temperature of oil and winding by dissipating heat that is generated due to losses within the transformer while in service. The number of sections per radiator and the number of radiators per transformer will depend upon the losses and permissible temperature rise.

Owing to transport limitation and possible transit damages, power transformers are provided with detachable radiators valves. At the time of dispatch, these radiators are detached and sent separately keeping the valves in position on tank flanges.

Each radiator consists of number of “Sections” made from pressed CRCA Sheets forming channels for oil flow. These “Sections” are welded to Header Pipes at Top & Bottom. Detachable radiators are provided with M.S. Flanges at Top & Bottom. Flanged radiators are fitted with Air Release Plug. Drain Plug. Lifting lug etc.

Bracing straps, made from MS Flat are provided on radiators to prevent vibration of sections.

Radiators are cleaned internally to remove scales and a coat of varnish is applied. External surface is cleaned off all rust and one coat of Red Oxide primer is applied which is followed by final painting.

Caution: Do not use bracing hooks for lifting of radiator. Lifting hooks for lifting of radiators are provided at the header pipes

6.9.1 Tank with Corrugated Walls (if Applicable)

A new concept in heat exchange by use of built in corrugation on transformer tank walls has virtually eliminated the radiator concept particularly for distribution transformers.

The corrugated walls panels are manufactured from CRCA sheet in thickness ranging between 1.2 mm and 1.5 mm.

The role of the corrugated panels is to increase the surface area of the tank, which is in contact with cooling air. Due to the temperature rise of windings under load the oil temperature also rises. The hot oil rises and meets the top cover and goes down into the fins where it is cooled by the air rising up between the walls.

As the panels are welded on transformer tank Keen attention is required during un-loading, handling and erection to protect from physical damages.

6.10 Pressure Relief Valve / Explosion Vent:

When specified, pressure relief valve is provided on the transformer tank. In case of heavy fault in transformer, this valve will operate and release pressure. When not specifically asked for, an explosion vent is provided on the tank cover. A special diaphragm provided on the vent will rupture in case of high pressure built up. However, unlike the pressure relief value, the ruptured diaphragm has to be replaced before putting the transformer back into service.

6.11 Silica Gel Breather:

Whenever there is a change in the ambient temperature or in the load of an oil immersed transformer, there is a change in oil temp & hence in the volume of oil. Increase in oil volume, causes the air above the oil level in the conservator to be pushed out and decrease causes air to be drawn in. Thus the transformer “Breathes”. When air is breathed in, there is a possibility of moisture and dust from atmosphere to be sucked in. These contaminants deteriorate the insulation properties of oil. Hence, Silica Gel Breather is provided which arrest moisture and dust from the air drawn in.

6.11.1 A Typical - Silica Gel Breather has following main components.

- A Casing
- Silica Gel Crystals,
- An oil seal at the lower end of Casting.

The casing is normally of transparent material for observation of the color of the gel crystals. It has a flange connection at the top for connecting the breather to the breather pipe. The lower part of the casing has at its lower end an oil seal arrangement, a window for observation of oil level and an oil-filling hole with gasket and plug.

Due to the chemical affinity possessed by Silica Gel Crystals, they absorb moisture from the air drawn in. The color of silica gel is blue when dry and turns pink when it is saturated with moisture indicating that it needs to be replaced. The color of crystals can be observed from outside of the casing.

Oil seal assembly at the lower end of the casing consists of a little quantity of oil with an inverted cup partly dipped in the oil and a tube fixed at the center of the cup.

The oil acts as a coarse filter and removes the dust from the outside air when passes through oil.

Silica gel breather is dispatched in a separate case. (Refer packing list)

6.12 Magnetic Oil Level Gauge (MOG):

This is a dial type oil level indicating device provided on large transformers with conservator at relatively high levels from the ground. Further, the low oil contacts provided on the magnetic oil level indicator can be used for automatic alarm when the oil level conservator falls to a low level. This protection feature and clear visibility justify the cost of MOG on a bigger transformer. It consists of two compartments:

A) The oil side compartment, which is fixed on the opening in the conservator.

B) The pointer side compartment.

These compartments are sealed against leakage of oil by a metallic diaphragm. On the oil side compartment, there is a level gear system operated through a float. Driving magnet is fixed to the bevel gear wheel and it is positioned near the diaphragm. Movement of the float due to rise and fall of oil level in the conservator results into circular motion of the driving magnet. A follower magnet is positioned in the pointer side compartment near the diaphragm. This magnet has its poles face to face the poles of driving magnet from the oil side compartment coupling them magnetically. The movement of float is, therefore, transferred through the diaphragm, eliminating direct oil tight mechanical coupling.

At the other end of the axis of the driven magnet an indicating pointer is fitted. The dial is calibrated to show the oil level in the conservator. The dial and the pointer are housed behind the front glass. The dial has three positions marked. The follower magnet has also a cam fitted on it, which operates a mercury switch. When this magnet is at a position corresponding to low oil level the mercury switch closes the Normally Open (NO) contacts. These contacts are normally wired to give audible alarm. The contacts are brought to a terminal box at the lower end of the dial, for external connections.

6.13 Oil temperature indicator (O.T.I.)

Oil temperature indicator (O.T.I.) is generally provided on all transformers. The direct reading pointer arrangement in this instrument greatly facilitates observation of working temp. of oil. It also helps, if need be, in deciding the permissible overloads in accordance with I.S. 6600-1972. Guide for loading of oil immersed transformers.

A Typical - Oil temperature indicator consists of a Bourdon tube with a pointer arrangement mounted in a case comprising a reading dial and a glass cover. There is a temperature-sensing bulb, which communicates to the Bourdon tube through the armored capillary.

The OTI temperature indicator is provided with two pointers and associated contacts for protection of transformers. Both the pointers are independently adjustable and can be set to desired temperatures. Setting of these pointers at required temperatures can be done from outside through the knob by using special keys.

The OTI is generally housed and wired up to terminal strip in the marshaling box having a glass window on the door for observation. The length of capillary does not influence the accuracy of measurement and extra length of capillary tubing must not be cut, as it would break communication between bulb and Bourdon tube.

If the oil temperature increases beyond set limit due to overload or inadvertent closure of radiator valves or insufficient air draft, the indicating pointer touches the preset alarm pointer and actuates the alarm contacts. The alarm contacts, when duly wired give an alarm. If the alarm is not attended and there is a further increase of temperature, the trip contacts, which are wired to the trip circuit, will operate and isolate the transformer from mains.

6.14 Winding Temperature Indicator (W.T.I.)

Generally for transformers of high power rating a Winding Temperature Indicator is also required.

A typical - Winding Temperature Indicating (W.T.I.) arrangement provided in a transformer comprises of the following:

(a) W.T.I. Pot (b) Image Coil (c) W.T.I. C.T.

The W.T.I. Pot is mounted at the top of the transformer tank. Hence the oil in the W.T.I. pot is at a temperature of TOP OIL. The image coil is a heater coil and develops additional heat raising the temperature of the oil inside the heater coil. There is a W.T.I. C.T. mounted on one of the line leads with its secondary feeding the image coil. As the load on the transformer varies, the line current varies, the W.T.I. C.T. secondary current passing through the Image Coil varies, the heat developed by Image coil varies and hence the temperature of the oil inside the Image Coil varies. The bulb of the W.T.I. is immersed in the oil inside the Image Coil and as seen above the temperature of this oil is dependent on Top Oil Temperature and the Load on the transformer.

The W.T.I. Image Coil is designed and calibrated to indicate the Winding Hot Spot Temperature (HST) because this is the temperature, which decides the life of the transformer. Thus the Winding Temperature Indicator (W.T.I.) reads temperature.

Winding Temperature Indicator is also housed in the marshaling box. W.T.I. also has an alarm and trip contacts, which are wired up to terminal strip.

CAUTION
Temperature Settings for OTI and WTI shall be as per requirement or as per GEW given drawings.

6.15 Thermo syphon Filter

Thermo syphon filter are intended for continuous filtration of transformer oil and are installed on transformers in the oil circuit. Thermo syphon is a filter is a container filled with an absorbent. As a result of difference between the upper and lower layer of oil in the transformer in operation, the oil circulates through filter from top to bottom. During the circulation, the absorbent removes the moisture from the oil. Certain acids and peroxides which speed up ageing of oil also gets removed

6.16 Nitrogen Injection Fire Prevention System (NIFPS) (If Applicable):

Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed for fire quenching and to prevent explosion of transformer tank and the fire during internal faults resulting from arc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a predetermined quantity of oil from the tank top through drain valve to reduce the tank pressure, Isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below Flash point

to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil Assembly)

Transformer is designed as per customer requirement with provision for NIFPS. Required arrangements provided in transformer are,

- Temperature detectors on top cover
- Nitrogen quick discharge valve/ Drain valve for NIFPS
- Nitrogen injection valves.
- Non return valve (NRV) mounting arrangement.
- Signal box mounting arrangement.

For mounting, functionality and operation, NIFPS manufacturer catalogue to be referred.

7. INSTALLATION

7.0 General:

This section illustrates procedure for installation & Commissioning of our transformers.

7.1 Location:

Before the transformer is moved to its permanent foundation or to a temporary storage area, the site must be carefully inspected.

Inspect the foundation of the transformer will be placed on. Ensure that its size and structural properties are correct for the transformer load. You might also confirm with the foundation engineering personnel to be sure. Also ensure that control wiring conduits or channels are in the correct position for the transformer control box (es), especially if supplied from underground (through the foundation surface).

Ensure that there are proper clearances around the transformer for

- Fire prevention equipment, fire walls, personnel safety.
- Noise barriers, fences, water deluge systems, ladders, etc.
- Cabling to control cabinets and for opening the cabinet doors
- Proper personnel access for construction and maintenance purposes
- Foundation should be firm, horizontal and dry. Where rollers are fitted, suitable rails should be provided.

The transformer should 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 a clear space of about 1.25 m on all sides of the transformer if it is enclosed in a room.

7.2 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.

7.3 Assembly of dismantled Components:

Various components dismantled for transportation should be duly assembled.(Refer OGA drawing)

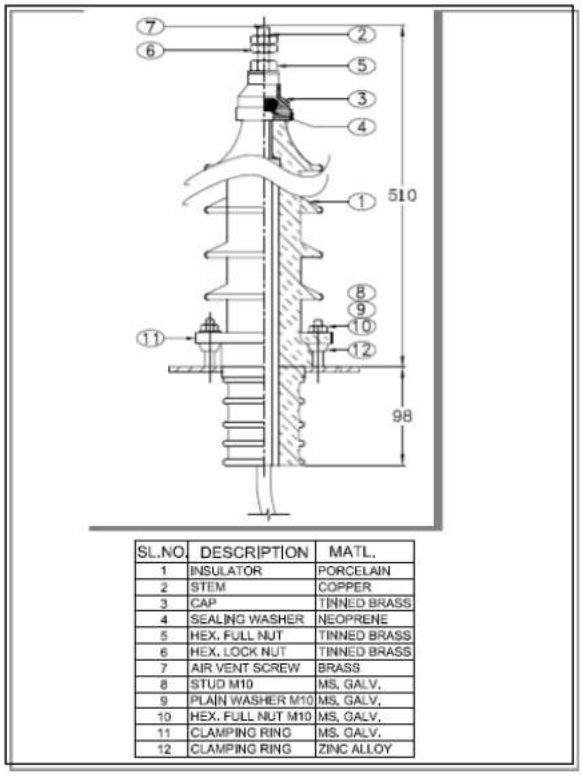
7.4 Main Tank:

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

7.5 Bushings:

7.5.1 Installation of Porcelain Bushings (1.1 - 52kV)

In general, 1.1-52 kV bushings will not be removed for shipment. However, in certain cases removal of the upper connector and/or porcelain may be required for shipment. The bushing is dismantled for packing.



SL.NO.	DESCRIPTION	MATL.
1	INSULATOR	PORCELAIN
2	STEM	COPPER
3	CAP	TINNED BRASS
4	SEALING WASHER	NEOPRENE
5	HEX. FULL NUT	TINNED BRASS
6	HEX. LOCK NUT	TINNED BRASS
7	AIR VENT SCREW	BRASS
8	STUD M10	MS, GALV.
9	PLAIN WASHER M10	MS, GALV.
10	HEX. FULL NUT M10	MS, GALV.
11	CLAMPING RING	MS, GALV.
12	CLAMPING RING	ZINC ALLOY

1. Dismantle the pre-assembled bushing and clean it and check that there are no hair line-cracks or other damages.
2. Remove the blind flange on the transformer tank (cover), remove the shipping gasket and clean up the gasket surface. Cover the opening for foreign parts, dust and moisture.
3. Screw the copper stem in the threaded hole (see detail A), in the internal connection, tighten them with the correct torque (see documentation for the specific bushing), so that the contact surface is correctly tightened, using nut and counter-nut on the top side of the stem. Mount the porcelain (together with the fixation ring) over the stem, using a new gasket. Make sure that the porcelain is correctly seated on the base, look for the correct positioning of the porcelain over the upper part (turn the porcelain so that the locking ring on the upper part of the stem does not damage the porcelain) of the stem. Draw the draw lead in the porcelain (in case of a draw lead conductor).
4. Mount the upper gaskets, the press rings and the lock nut, without tightening them.
5. Tighten the fixation ring carefully, first by hand and then progressively tighten the bolts with the correct torque (see documentation for the specific bushing).

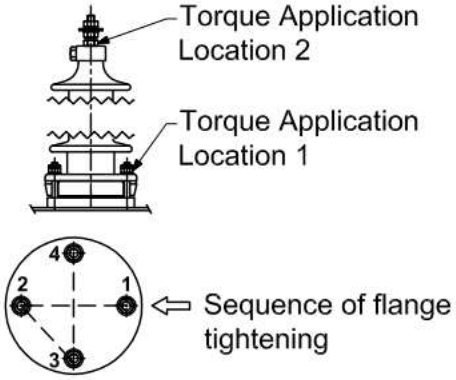
   Tighten the lock nut with the correct torque (see documentation attached for the specific bushing).

NOTE
For draw lead bushings (for current ratings of 630 Amps and below), the lower part of the copper stem is replaced by a flexible copper conductor. There are no internal connections to be made in that case.

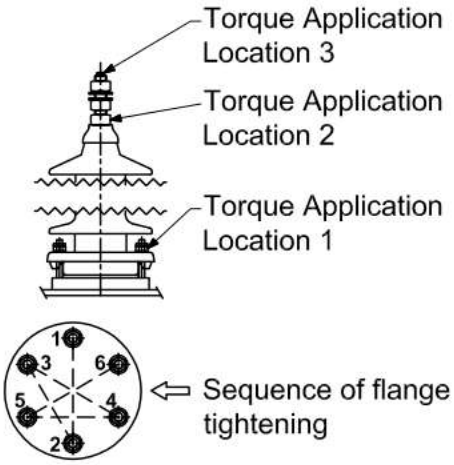
General Engineering Works
Transformer Division

Torque Application Chart for Porcelain Bushings

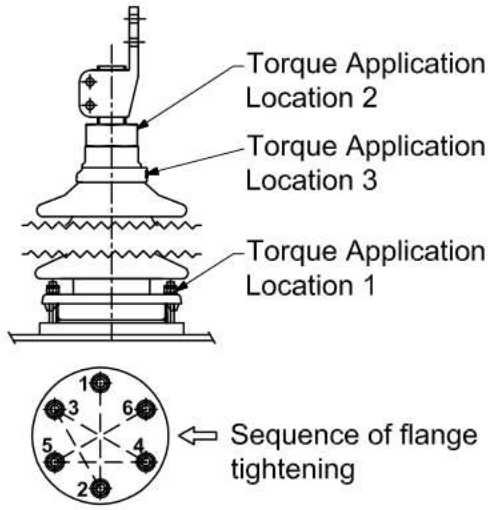
(1.1 kV, 12/17.5 kV, 36 kV & 52 kV class)



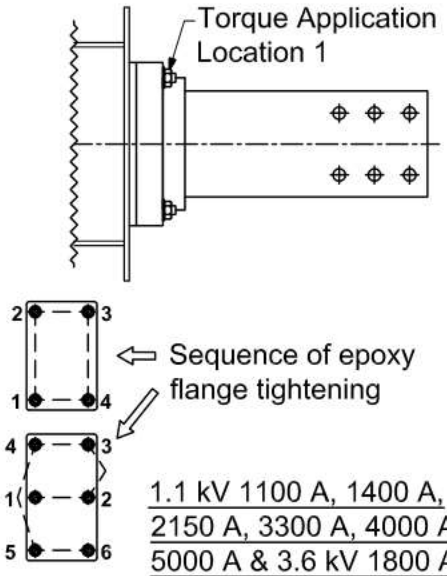
17.5 & 36 kV 250 A Porcelain bsg.



17.5 & 36 kV 630 A Porcelain bsg.



17.5 & 36 kV 1000, 2000 & 3150 A Porcelain bsg.& 52 kV 1000 A Porcelain bsg.



1.1 kV 1100 A, 1400 A, 2150 A, 3300 A, 4000 A, 5000 A & 3.6 kV 1800 A Epoxy Bushing

Porcelain Bushing Rating	Location 1		Location 2		Location 3	
	Size (mm)	Torque (Nm)	Size (mm)	Torque (Nm)	Size (mm)	Torque (Nm)
17.5 & 36 kV 250 A	M10	10	M12	15	-	-
17.5 & 36 kV 630 A	M10	10	M20	20	M6	5
17.5 & 36 kV 1000 A	M12	15	M30	60	M6	5
17.5 & 36 kV 2000 A	M12	15	M42	105	M6	5
17.5 & 36 kV 3150 A	M12	15	M48	130	M6	5
52 kV 1000 A	M12	15	M30	75	M8	5

Epoxy Cast Bushing Rating	Location 1	
	Size (mm)	Torque (Nm)
1.1 kV 1100 A	M10	15
1.1 kV 1400 A	M10	15
1.1 kV 2150 A	M10	15
1.1 kV 3300 A	M10	15
1.1 kV 4000 A	M10	25
1.1 kV 5000 A	M12	25
3.6 kV 1800 A	M10	20

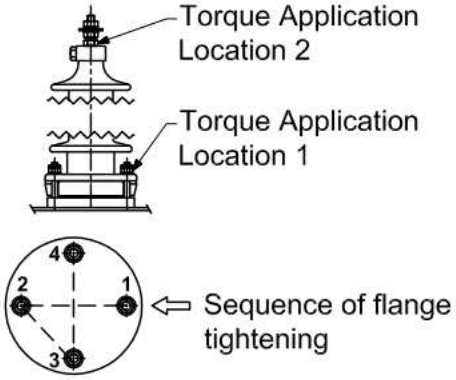
Note:

1. **Follow the torque chart given above to tighten the bushings which are to be assembled at site**
2. Tolerance value on tightening torque is ±10%
3. Use the specified tightening sequence and recommended bolt torque values
4. Use an accurate torque wrench to tighten the nuts in three to five incremental steps, following the recommended sequence and torque specifications for the application

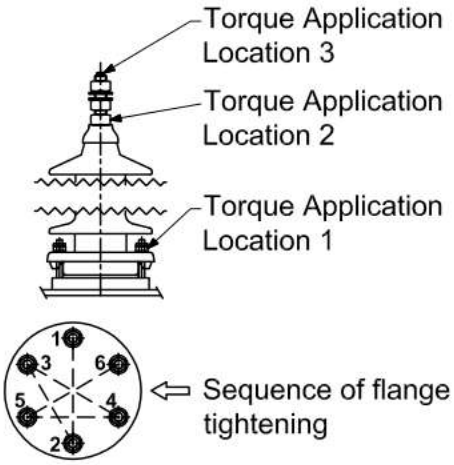
General Engineering Works
Transformer Division

Torque Application Chart for Porcelain Bushings

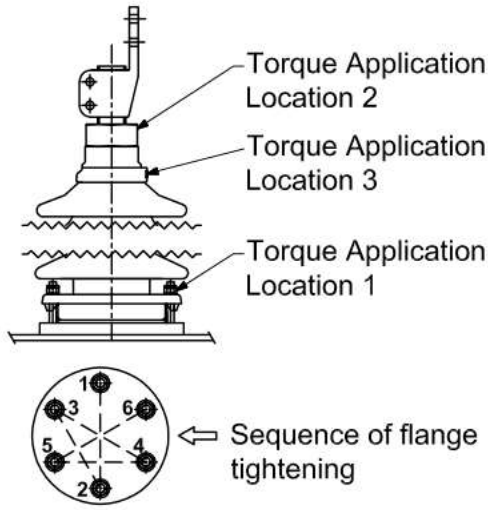
(1.1 kV, 12/17.5 kV, 36 kV & 52 kV class)



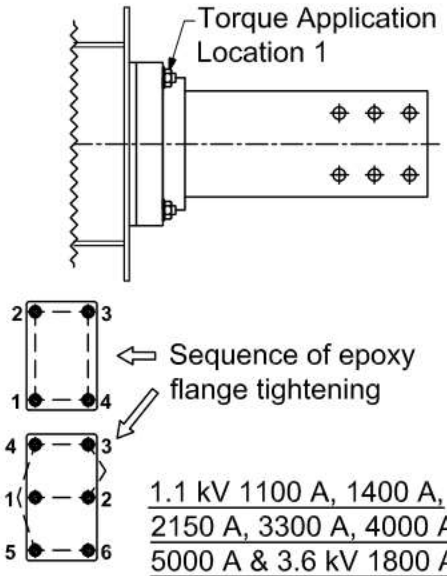
17.5 & 36 kV 250 A Porcelain bsg.



17.5 & 36 kV 630 A Porcelain bsg.



17.5 & 36 kV 1000, 2000 & 3150 A Porcelain bsg.& 52 kV 1000 A Porcelain bsg.



1.1 kV 1100 A, 1400 A, 2150 A, 3300 A, 4000 A, 5000 A & 3.6 kV 1800 A Epoxy Bushing

Porcelain Bushing Rating	Location 1		Location 2		Location 3	
	Size (mm)	Torque (Nm)	Size (mm)	Torque (Nm)	Size (mm)	Torque (Nm)
17.5 & 36 kV 250 A	M10	10	M12	15	-	-
17.5 & 36 kV 630 A	M10	10	M20	20	M6	5
17.5 & 36 kV 1000 A	M12	15	M30	60	M6	5
17.5 & 36 kV 2000 A	M12	15	M42	105	M6	5
17.5 & 36 kV 3150 A	M12	15	M48	130	M6	5
52 kV 1000 A	M12	15	M30	75	M8	5

Epoxy Cast Bushing Rating	Location 1	
	Size (mm)	Torque (Nm)
1.1 kV 1100 A	M10	15
1.1 kV 1400 A	M10	15
1.1 kV 2150 A	M10	15
1.1 kV 3300 A	M10	15
1.1 kV 4000 A	M10	25
1.1 kV 5000 A	M12	25
3.6 kV 1800 A	M10	20

Note:

1. **Follow the torque chart given above to tighten the bushings which are to be assembled at site**
2. Tolerance value on tightening torque is ±10%
3. Use the specified tightening sequence and recommended bolt torque values
4. Use an accurate torque wrench to tighten the nuts in three to five incremental steps, following the recommended sequence and torque specifications for the application

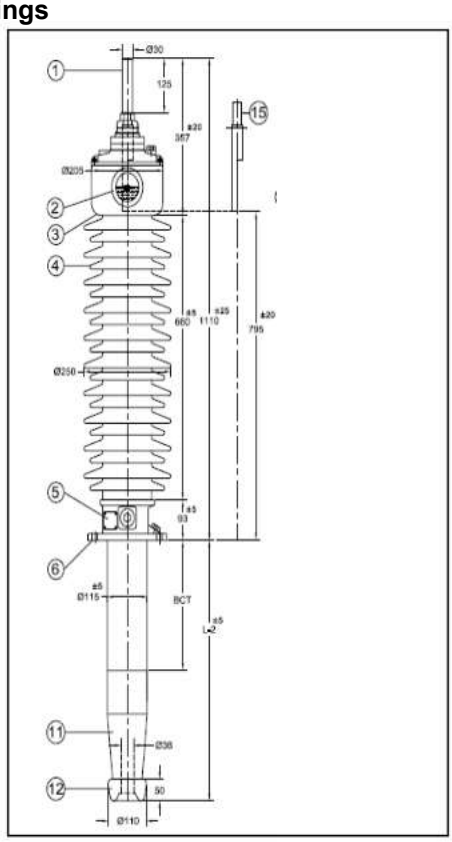
7.5.2 Installation of Condenser Bushings

Condenser type bushings incorporate a capacitive voltage grading system to carefully control the electric field inside the bushing. This allows a minimum partial discharge design that is very important in many applications, especially when voltage ratings increase. Most condenser bushings are oil-filled and the internal parts are oil impregnated. Condenser bushings often incorporate a capacitive tap, where the final capacitive foil (the ground layer) is brought out through a special test tap. This test tap may be used for monitoring purposes as well as for testing the bushing. The test tap must be directly grounded or fixed to the ground over the monitoring device.

7.5.2.1 Different types of condenser bushings

Check the *General Arrangement Drawing* to find out which bushing type is used. Some of the bushings may come with a corona shield that is usually manufactured from spun aluminum and is quite delicate. The shield must not be bent. The coronal shields are usually shipped separate from the bushings, in well-padded packaging. Ensure that the shield is properly attached to the bushing and all mounting bolts are tightened prior to installing the bushing.

A) Draw lead condenser bushings



ITEM	QTY	DESCRIPTION
1	1	H.V. TERMINAL
2	1	OIL INDICATOR(FLOAT)
3	1	CONSERVATOR
4	1	AIR END INSULATOR
5	1	RATING PLATE
6	1	MOUNTING FLANGE
7	1	TEST TAP ASSLY.
8	1	OIL FILLING/SAMPLING VALVE
9	1	AIR VENT PLUG
10	1	CONDENSER CORE
11	1	OIL END INSULATOR
12	1	ELECTRODE
13	1	SEALING RING
14	1	LOCKING PIN
15	1	THIMBLE

Figure: Draw lead condenser bushing

Draw lead bushings are designed up to 800 amps depending on the specific bushing design. For higher currents, the bottom connected design will be used.

Draw lead condenser bushings are hollow bushings through which the draw lead has to be pulled during installation. No other access is necessary.

The winding lead cable is brazed or crimped to connect to the terminal-stud at the factory. The cable is coiled and tied securely to the blind flange or to the active part assembly for shipment. The same needs to be carefully taken out during installation at site

7.5.2.2 Bottom connected condenser Bushings

Bottom connected condenser bushings are bushings for a current of 800 amps or more. A bottom connected condenser bushing has a solid core to which the internal winding lead has to be connected through a separate hand hole or any other opening provided on tank cover or tank side walls..

Bottom connected condenser bushings are bushings for a current of 800 amps or more. A bottom connected condenser bushing has a solid core to which the internal winding lead has to be connected through a separate hand hole or any other opening provided on tank cover or tank side walls..

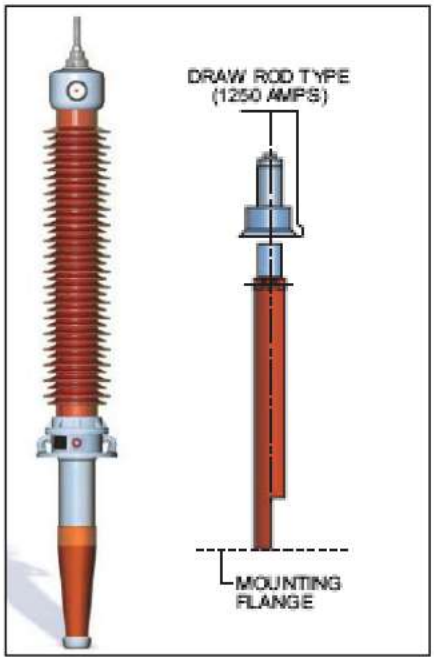


Figure: Bottom Connected Condenser Bushing

7.5.3 Mounting Instructions

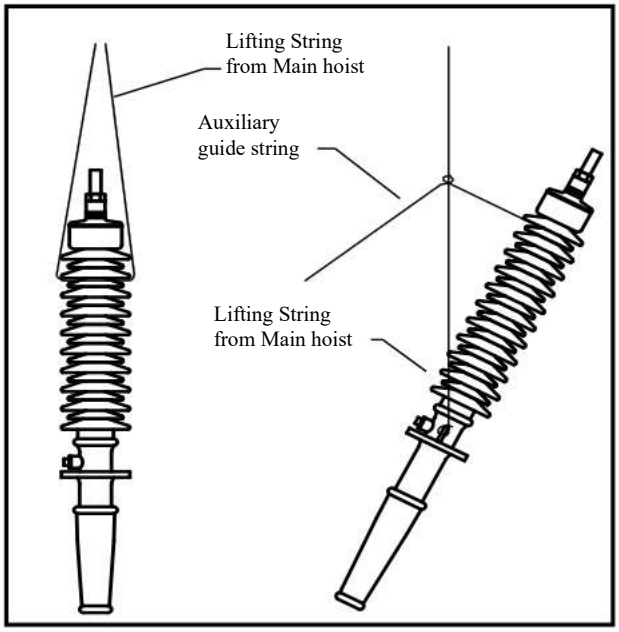


Figure: Lifting Instruction for Condenser bushing

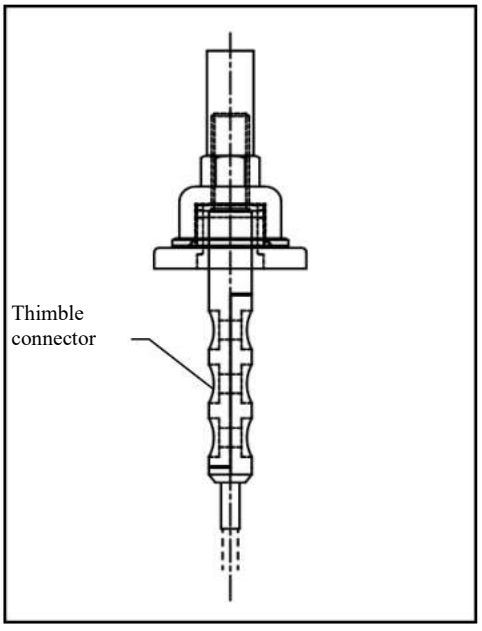


Figure: Draw Lead Condenser bushing

7.5.3.1 Draw lead condenser bushing

1. Unpack the bushing keeping it tilted with the top side higher than the bottom side to avoid air bubbles penetrating the insulation at the bottom.
2. Check the bushing carefully (for oil leaks as well). Check the centre tube and remove the plastic sealing plugs if present
3. Remove the outer terminal cap on the top of the bushing.
4. Clean the porcelain using clean rags, moisturized with Methyl Hydrate if needed.
5. If the terminals are dirty, clean them with clean, dry rags (moisturized with Methyl Hydrate if necessary) or use a soft brush.
6. Remove the blind flange on the transformer tank (cover), pull out the draw lead and check for damage, remove the shipping gasket and clean the gasket surface.
7. Place a new gasket on the cover and cover the opening for foreign parts, dust and moisture.
8. Sling the bushing at the correct angle according to Figure 17
9. Attach a strong cord or wire to the terminal stud and pull it through the central tube of the bushing.
10. Slowly draw the draw lead cable in the bushing while the bushing is placed into position. Fix the bushing flange into position and mount the upper terminal stud and cap (refer to the specific documentation for the bushing).
11. Tighten the top terminal arrangement and the flange bolts with the correct torque according to the specific documentation.
12. Ground the bushing for personnel safety as well as to ensure that the transformer will not be damaged due to lightning

CAUTION
When slowly lowering the bushing through the turret or mounting hole in the tank, make sure that you do not damage the current transformers mounted around the entry hole. There is only a small clearance available between the bushing and the current transformer. Bushings mounted at an angle must be lowered into position maintaining that angle.

7.5.3.2 Bottom connected bushings

The same figures and caution Remarks apply as for draw lead condenser bushings.

1. Unpack the bushing keeping it tilted with the top side higher than the bottom side to avoid air bubbles penetrating the insulation at the bottom.
2. Check the bushing carefully (also for oil leaks) and clean the porcelain using clean rags (moisturized with Methyl Hydrate if necessary).
3. If the terminals are dirty, clean them with clean, dry rags (moisturized with Methyl Hydrate if necessary) or use a soft brush.
4. Remove the blind flange on the transformer tank (cover), remove the shipping gasket and clean the gasket surface.
5. Place a new gasket on the cover and cover the opening for foreign parts, dust and moisture.
6. Sling the bushing at the correct angle according to Figure 30.
7. Mount the bushing into position. Tighten the bushing flange bolts according to the specific documentation for the bushing.
8. Make the internal connection through the hand hole or manhole.
9. Tighten the bolts according to the specific information for this bushing.
10. Close the handhole or manhole carefully.
11. Ground the bushing for personnel safety as well as to ensure that the transformer will not be damaged due to lightning.

7.6 Installation of oil-filled cable boxes

This is a typical principal drawing of a HV oil-filled cable box.

The bushing is an oil / oil condenser bushing.

The cable sealing end is usually a sealed and closed termination that has a mounting flange to bolt it on the cable box bottom.

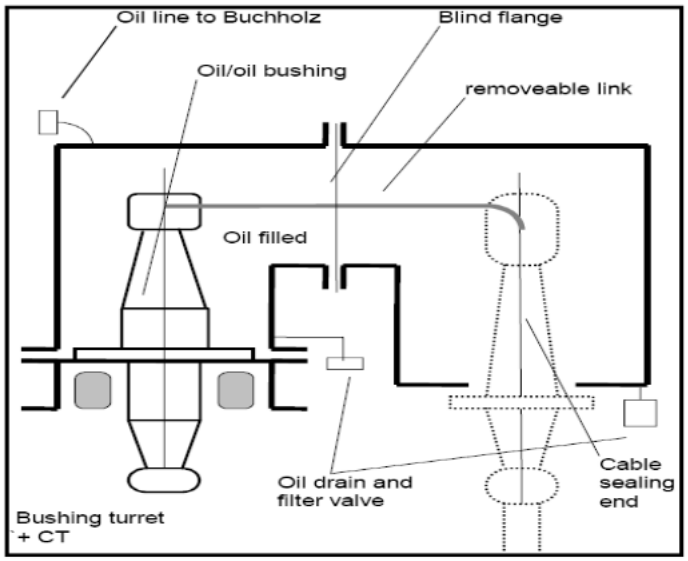
There is a removable link that can be removed for the dielectric test on the cable termination.
Drain and filter facilities are usually provided.

A part of the cable box or all parts may have been removed for shipment

7.6.3 Mounting instructions

1. Mount the oil / oil condenser bushing in the same way as a normal condenser bushing (refer to the previous instructions).
2. In most cases, the cable sealing end will be installed in a later stage. To prevent moisture damage on the bushings proceed as follows:
3. Mount the left part (see drawing) of the cable box. Provide a blind flange and fill up this part of the cable box with clean and dry insulation oil up to 90%. Fill the gas space with nitrogen under a light overpressure. The oil may be removed just before the final assembly of the cable sealing end.
4. Mount the cable box, using new gaskets and tighten all bolts according to the general instructions previously described in this section
5. Mount the oil pipes and valves to the buchholz relay or conservator using new gaskets.
6. Mount the cable sealing end and the removable links between the transformer bushing and the cable sealing end.
7. Fill up the cable box (possibly under vacuum) with clean dry insulation oil. The oil quality should be the same as for the transformer (see further in this section).

If any dielectric tests are to be performed on the cable sealing end, all transformer bushings must be grounded and protected carefully. If DC- test voltages are required, refer to the manufacturer's instructions about requirements for minimum clearances and oil quality.



CAUTION
Before drawing vacuum and/or filling with oil, check the *General Arrangement Drawing*, *Cable Box Drawing(s)*, the nameplate and documentation of the sealing end to ensure that all parts are full vacuum proof and that they may be used under oil.

7.7 Radiators:

Note the details of Radiators and Radiator Valves in the “Commissioning Report”. Mount the radiators as outlined below:

i) Radiators are to be assembled only one at a time.

ii) 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.

iii) Fill the conservator full using an oil filter machine.

iv) Clean each radiator externally, remove blanking plates and clean the gaskets and radiator flanges. If gaskets are damaged, use spare gaskets.

v) 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.

vi) 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.

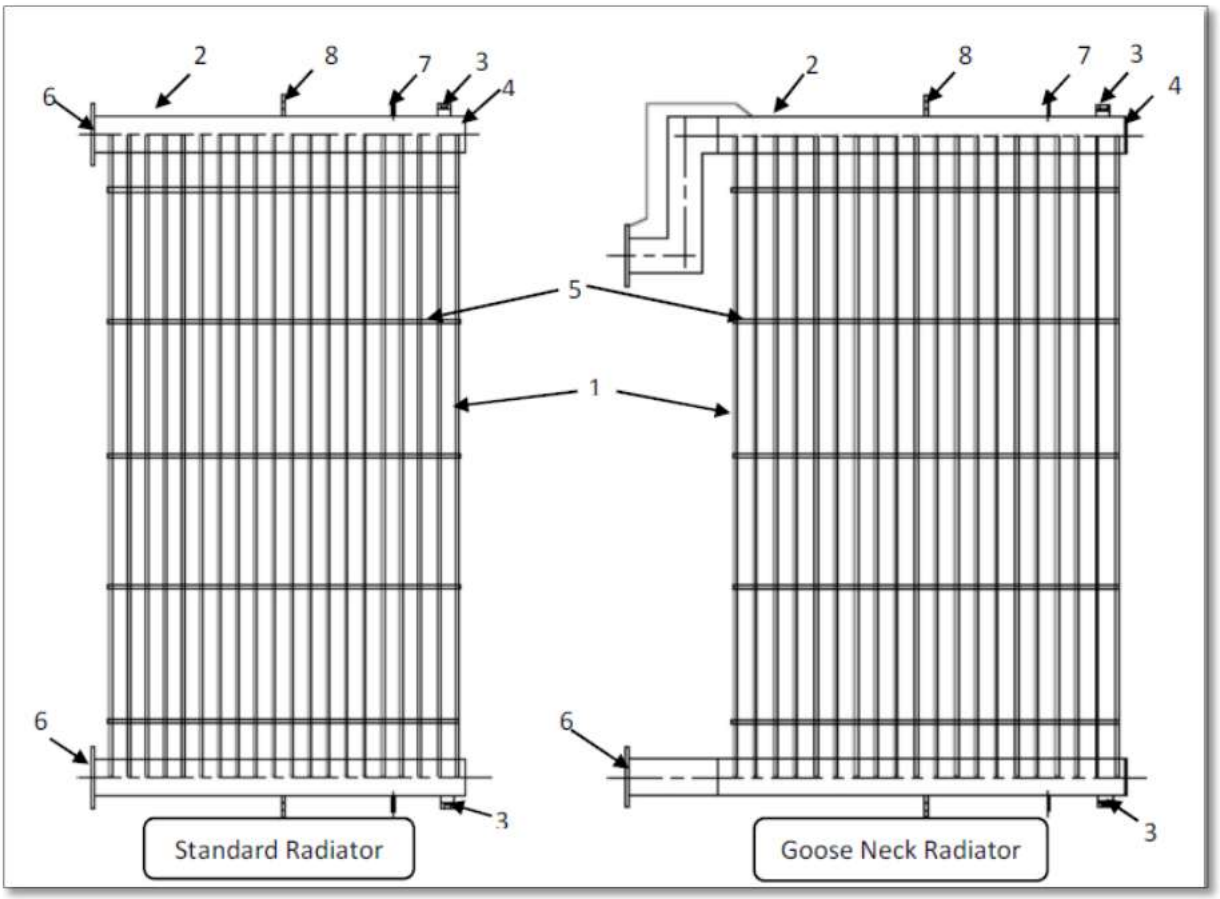
vii) Bring the radiator flanges close the flanges on the tank. Ensure that tank flange gasket is in position. Fit by means of bolts, nuts, washers etc.

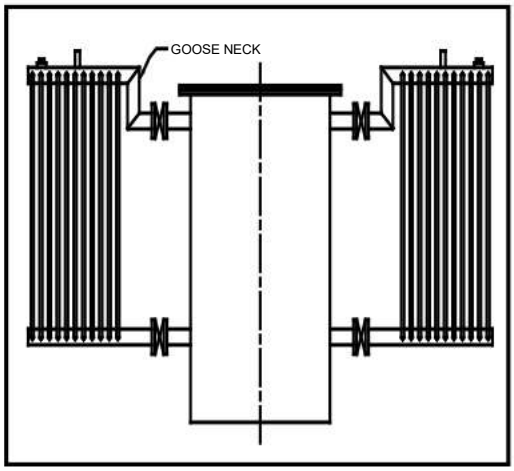
viii) Open the bottom radiator valve using the operating handle. Gradually unscrew the air release plug on the top of the radiator until air starts escaping. Air release plug should not be removed from the engaging threads, as it would be difficult to control oil coming out of it. Oil from main tank will how flow in the radiator, driving out air from air release plug. 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 form the radiator itself and the gasketed joints. Restore the oil level and assemble the next radiator in the same manner.

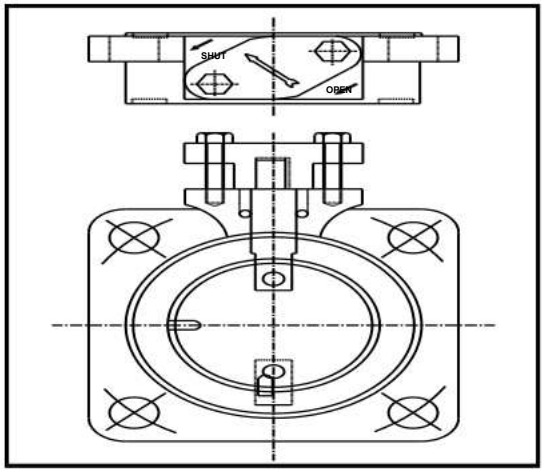
Assembly of radiators should be preceded in only one direction clockwise or anti clockwise. After filling last radiator, oil level in conservator should be restored only up to the filling mark.

CAUTION
Never lift radiators by the spot welded side rods.
Always use the lifting lugs on top.
Always have Goose (Extension) on Top side in case of Goose Neck radiators

Caution: Do not use bracing hooks for lifting of radiator. Lifting hooks for lifting of radiators are provided at the header pipes





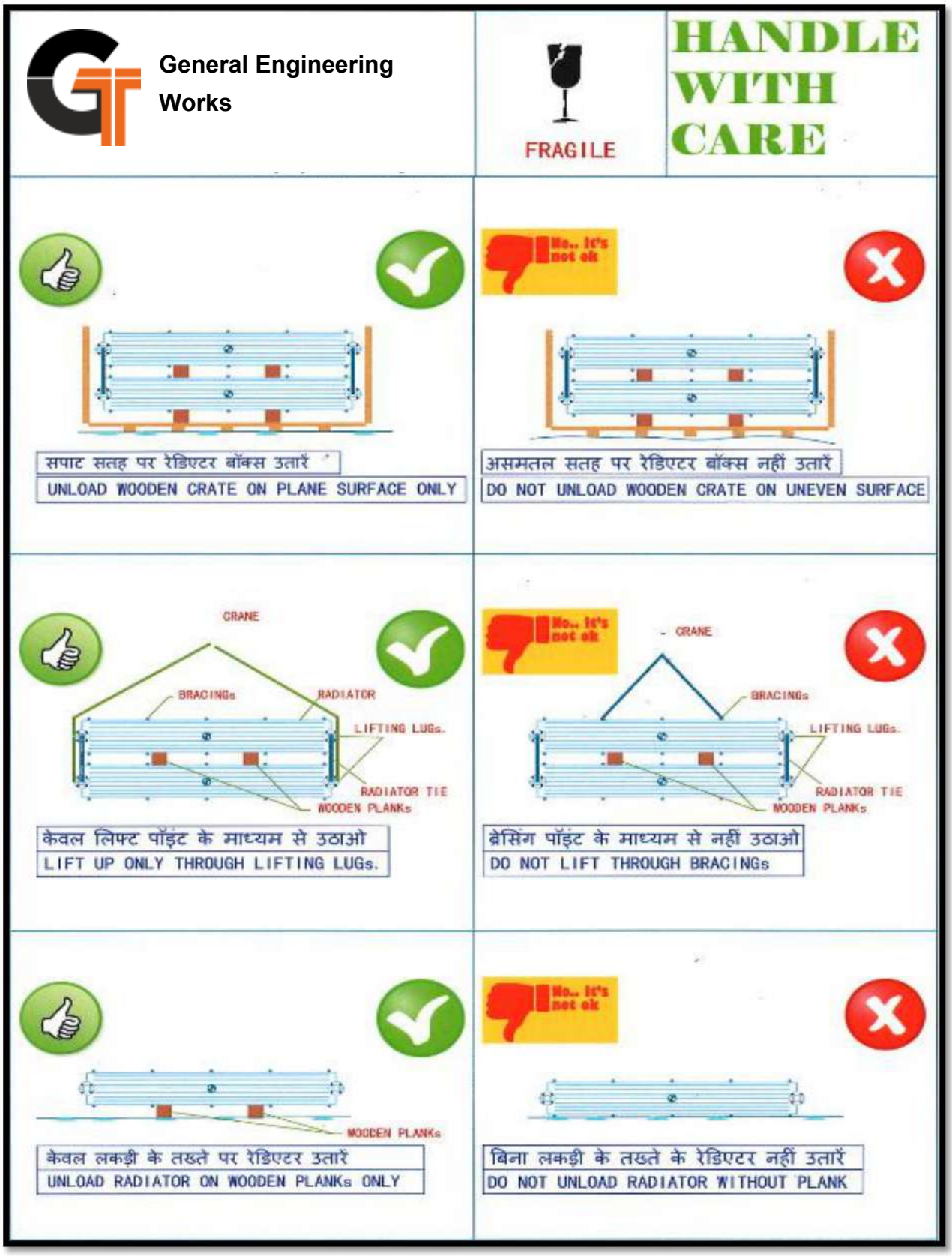


Radiator Valve

Legends

1. Cooling Element
2. Header Pipe
3. Air Release plug and Drain Plug
4. End Plate
5. Stiffener
6. Mounting Flange
7. Brazing Lug
8. Lifting Lug

Following are the Dos-Donts to be follow while handling with the Radiators



7.8 Wiring on the transformer

The wiring on the transformer is always completed and checked during assembly in the factory. However, the connection between transformer and remote control cabinets is only made as a temporary base for testing.

During disassembly for shipment of the transformer, some parts with an electrical connection must be disconnected. This will result in free cable-ends (or free plug-ends) that can be situated on the dismantled part or on the transformer. Free cable ends will be coiled and protected by plastic bags or another protection and tied to the transformer tank or assemblies. The wires of free cable-ends are marked with the same terminal number as the terminal to which they have to be connected during the final wiring on site.

Current transformer circuits have been short circuited before and during transportation for safety purposes. This short circuit wire has to be removed at the time of final wiring and/or testing.

The following wiring types are used:

- Cabling with a certain cable type. The cables are mounted onto the transformer with the help of cable ties and saddles.
- Wiring into conduits or cable trays (galvanized or in aluminium) that are fixed on the transformer tank is done on request.

7.8.1 Marshalling Box (MB / Fan Control Cubical (FCC) :

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.

Set the ‘Alarm’ & ‘Trip’ contacts of O.T.I. & W.T.I. at required values. O.T.I. settings of A=85^{o}C & T=95^{o}C & W.T.I. setting of A=95^{o}C & T-105^{o}C are considered good. They can be worked out to suit local conditions.

All the protective devices (MOG, Buchholz Relay, PRD etc.) wiring are laid to marshalling box with proper ferrule identification. Details of Wiring and its termination can be refereed by the respective wiring drawing.

Note details of O.T.I. & W.T.I. and their settings in the “Commissioning Report”.

7.8.2 Drive Mechanism (DM) for OLTC:

DM Box already mounted on its required position. OSR and PRD wiring are laid to DM box with proper ferrule identification. Details of Wiring and its termination can be referred by the respective wiring drawing.

Interconnection of DM box wiring with RTCC wiring shall be done at site with correct routing and suitable cable sizes. Wiring Interconnection details are provided in the wiring schematic terminal plan

7.8.3 Remote tap Changer Control Cubical (RTCC) for OLTC:

RTCC panel send separately and to be commissioned / fixed in indoor type control room. RTCC indicates various types of indications as detailed below,

Interconnection of RTCC panel wiring with DM box wiring and marshalling box wiring shall be done at site with correct routing and suitable cable sizes. Wiring Interconnection details are provided in the wiring schematic terminal plan.

Table: Indication of various Instruments

Sr. No	Indication	Purpose	Remarks
1	TPI (Tap Position Indicator)	Display of tap position of OLTC	
2	AVR (Automatic Voltage Regulator)	Automatically changes the tap position of OLTC.	If Provided
3	Remote Temperature Indicator	Display Oil Temperature and Winding Temperature of the transformer	If Provided
4	Annunciator	It is a Multi-display window device which Indicates various indications related to transformer monitoring system / Protection devices	If Provided
5	LED	LEDs indications are used for indicating various alarm / trip / failure / Healthy conditions of transformer and its accessories	If Provided
6	Hooter	Hooters are used for creating sounds during alarm / trip / failure / Healthy conditions of transformer and its accessories	If Provided

Caution:

1. Ensure Proper Earthing of DM box, RTCC panel, Marshalling Box before energising
2. All Interconnections between OLTC-RTCC-MB are done as per drawing (refer Terminal Plan for interconnections).
3. Ensure connected supply source shall be as per relevant drawing to avoid damage of the Equipments.
4. Ensure correct polarity connected in case of DC supply application to avoid damage of Equipments.
5. In case of any equipment defect observed at site report immediately.

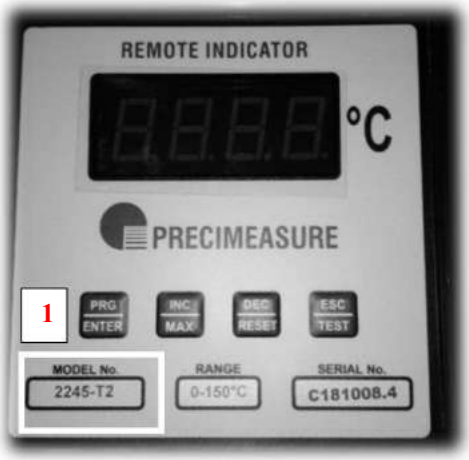
Chart of Models with Compatible Options (If provided)

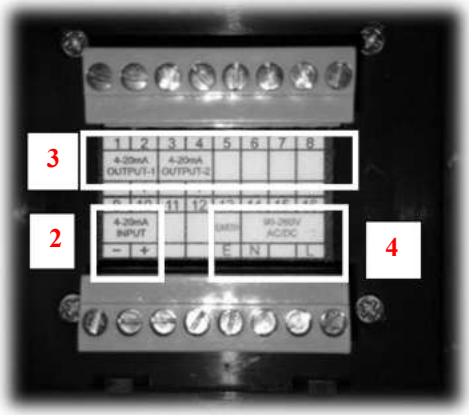
WTI / OTI - Models	Repeater-Model	CCU	PT100
1031(WTI/OTI)	NA	NA	NA
1031H (WTI/OTI)	2245-T2/T5	External	Inbuilt
1007 (WTI/OTI)	NA	NA	NA
1007H (WTI/OTI)	2245H-T2/T5	Inbuilt	NA
1005A (WTI/OTI)	NA	NA	NA
1005AH (WTI/OTI)	2245H-T2/T5	Inbuilt	NA
2220-R2(External-CCU)(WTI/OTI)	2245-T2/T5	-----	External

Following Steps should take care during Testing WTI/OTI, CCU with Repeater:

Do's	Don'ts
1. All connection should be right & tight as per Drawing. 2. Check compatible model of RTI for Fixed WTI/OTI. 3. Check compatible model of RTI for Fixed CCU. 4. Check Connections of PT100 with CCU. 5. Check input supply wires are connected to supply terminals only, refer drawing for details	1. Do not connect input supply wires to 4-20mA terminals or Local OTI/WTI terminals on repeater/CCU same may damage to device. 2. While doing 2 kV HV test on Wiring of Marshalling Box all electronic Devices **(WTI/OTI, CCU, RTI, AVR, TPI, Annunciator, kV meters etc.)** terminals Shall be Disconnected

BASIC INFORMATION FOR OTI, WTI REPEATER (IF PROVIDED)





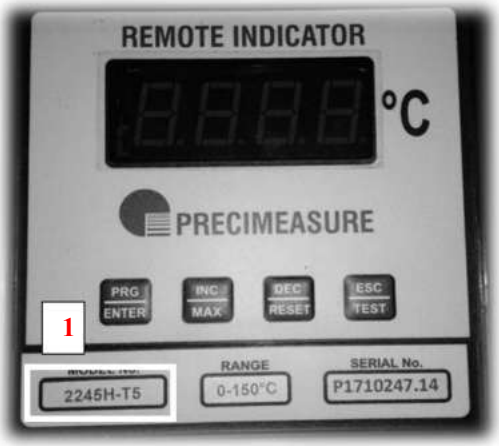
No.	Function (Repeater)	Terminal Number
1	Model No.	2245-T2
2	4-20 mA Input from CCU	9-10
3	4-20 mA Output	1-2, 3-4
4	1 Phase Input Supply	Phase-16, Neutral-14, Earth-13

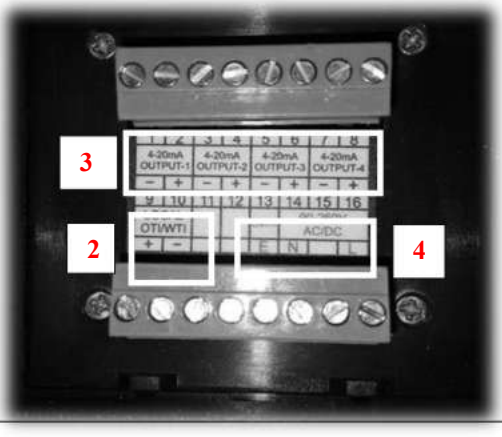
Instructions:

1. Check input supply wires (90-260 Volts AC/DC) are connected to supply terminals (16-P, 14-N, E-13) only, refer drawing for details.
2. Connect 4-20mA output of CCU to repeater input terminal No. 9-10.
3. Terminal 1 to 4 are 4-20mA output for remote use.
4. For Programming details refer catalogue.

Caution:

1. Please check the connections and terminal Voltage **(Should be between 90-260 Volts AC/DC)** before connecting the supply terminals.
2. Do not connect input supply wires to 4-20mA terminals or Local OTI/WTI terminals on repeater/CCU same may damage to device.
3. Ensure correct polarity connected to respective terminals.





No.	Function (Repeater)	Terminal Number
1	Model No.	2245H-T5
2	4-20 mA Input from Local WTI/OTI	9-10
3	4-20 mA Output	1-2, 3-4,5-6, 7-8
4	1 Phase Input Supply	Phase-16, Neutral-14, Earth-13

Instructions:

1. Check input supply wires (90-260 Volts AC/DC) are connected to supply terminals (16-P, 14-N, E-13) only, refer drawing for details.
2. Connect output of WTI/OTI CCU to input of repeater terminal No. 9-10.
3. Terminal 1 to 8 are 4-20mA output for remote use.
4. For Programming details refer catalogue.

Caution:

1. Please check the connections and terminal Voltage **(Should be between 90-260 Volts AC/DC)** before connecting the supply terminals.
2. Do not connect input supply wires to 4-20mA terminals or Local OTI/WTI terminals on repeater/CCU same may damage to device.
3. Ensure correct polarity connected to respective terminals.

7.9 Conservator:

1. Unpack all components, check them and clean all gasket surfaces.
2. Mount the conservator support(s).
3. Mount the conservator on its supports (bolts are not to be tightened at this time).
4. Mount the oil pipes on the cover, including new gaskets (bolts are not to be tightened at this time):

- The oil connection between tank and conservator.
- The oil connection between bushing turrets and the oil pipe (if any).
- The oil connection between the tap changer head and its conservator.

5. Mount the vertical oil pipes and their components including new gaskets (bolts are not to be tightened at this time):

- The oil drain valve(s) (OLTC and main conservator).
- The pipe to the silica gel breather and the breather itself.

If all components are in place, tighten the bolts on the pipe connections in the same sequence as you have mounted them. Then tighten the bolts on the conservator support(s).

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 separately as per Drawing.

There may be one of the following types of Conservator provided with the transformer.

- Non-Air Cell (COPS) type Conservator
- Air Cell (COPS) type Conservator

7.9.1 Non - Air Cell (COPS) conservator

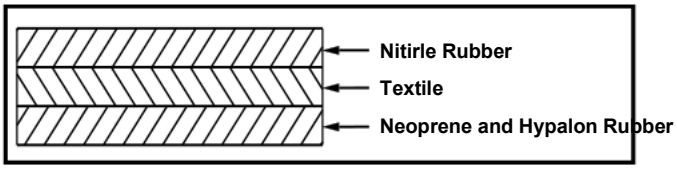
A non-COPS type conservator has been used in order to take into account the rise and fall of the oil level due to changes in transformer loading and ambient temperature. The main tank is connected to the conservator through a pipe equipped with a valve. The air space in the conservator is directly in contact with the oil and it is connected to the atmosphere through a dehydrating breather.
This system requires a small amount of maintenance; ensure that the silica gel is replaced when needed. The period of time between two replacements depends on a number of factors such as relative humidity and rate of change of loading and ambient temperatures. This cannot be predicted in advance, periodic inspection is necessary.

To allow sufficient space for oil expansion, the internal capacity of the conservator is defined by the specified load and ambient temperatures listed in the standard and/or specifications. Furthermore, the conservator is provided with adequate access for cleaning, a shut-off valve to the main tank, and filling / draining devices.

For most load tap changer transformers the conservator contains a separate section for the OLTC (completely separate, no liquid intermixing). Some OLTC designs may have a small, separate conservator. These will be clearly indicated on the *General Arrangement Drawing.*

7.9.2 Air Cell (COPS) type conservator

In the COPS type conservator the oil is completely separated from the open air in order to prevent moisture contamination of the oil. The expansion air cell is made of nitrile rubber.



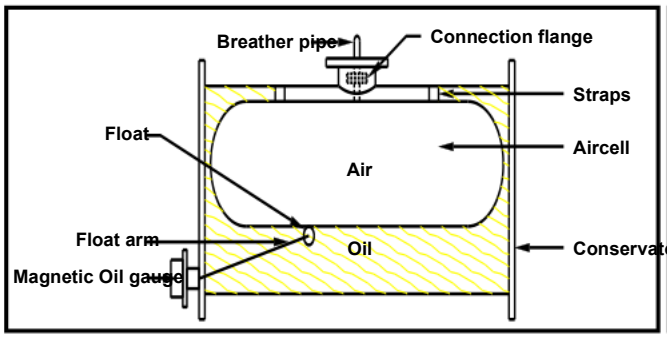


Figure 1 Example of conservator membrane

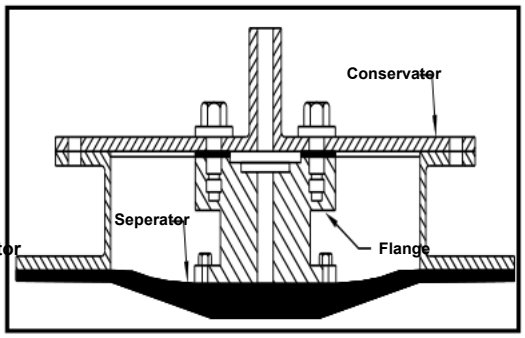


Figure 2 Conservator aircell connection

A flange and two suspension hooks are vulcanized to the upper side of the membrane. The membrane is suspended on the inside of the vessel by means of the suspension hooks. The air connection is made through the special flange.

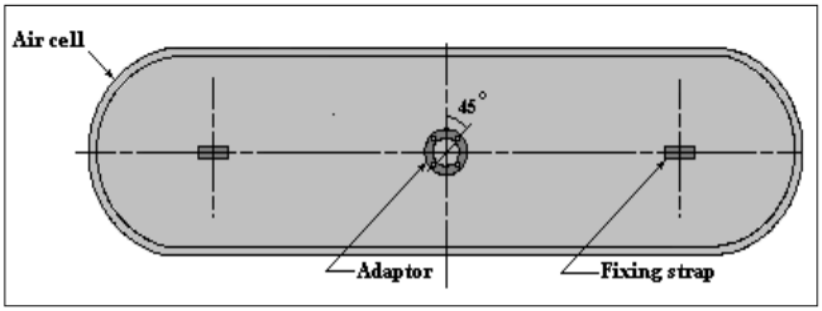


Figure 2 Conservator air cell connection

When the oil temperature increases in the transformer, the oil will expand in the conservator. As the air cell opening is connected to the outside air through a dehydrating breather containing silica gel, the expanded oil will force the air cell to contract. The oil is only in contact with the outside rubber of the air cell. In other words, there is no contact between the oil and the air.

The only maintenance consists in a regular control of the silica gel colour. The air cell is dust and oil proof. It only needs a periodic control through the inspection opening (manholes). When a split or leakage occurs in the air cell, the system continues to work on the principle of the normal non-air cell type conservator with the dehydrating breather preventing moisture from contaminating the oil. Furthermore, the oil penetrates the air cell, the air cell sinks to the bottom of the tank and the minimum contact of the level gauge gives a signaling contact

Caution: Air Cell type conservators will never show correct oil level in the prismatic oil level gauge. Always refer to the Magnetic Oil Level Gauge provided.

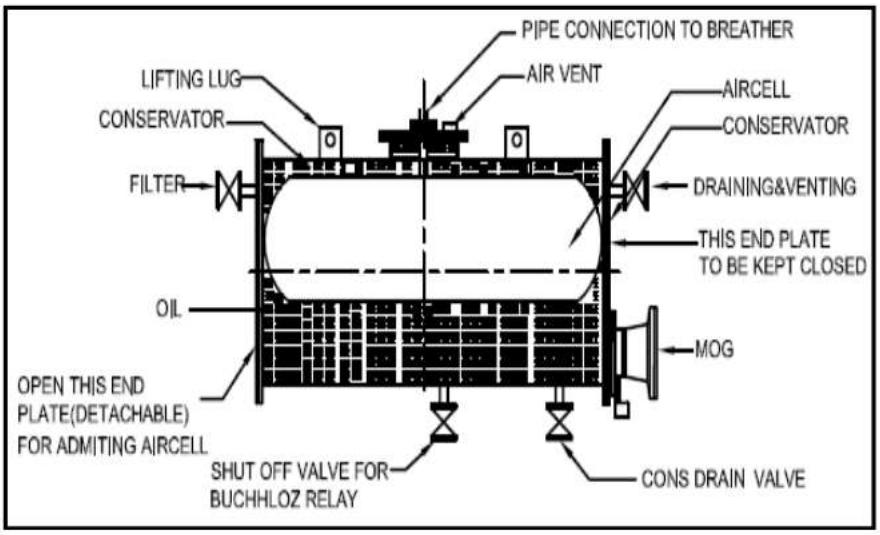
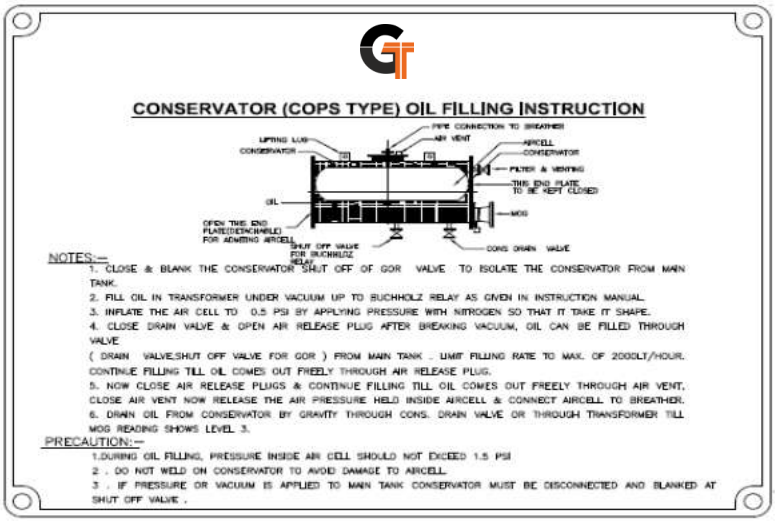


Figure: Schematic representation of Air Cell (COPS) type conservator

A plate as shown here is mounted on the transformer detailing complete procedure of installing and charging an air cell.



CONSERVATOR (COPS TYPE) OIL FILLING INSTRUCTION

NOTES:—

1. CLOSE & BLANK THE CONSERVATOR SHUT OFF OF GOR VALVE TO ISOLATE THE CONSERVATOR FROM MAIN TANK.
2. FILL OIL IN TRANSFORMER UNDER VACUUM UP TO BUCHHOLZ RELAY AS GIVEN IN INSTRUCTION MANUAL.
3. INFLATE THE AIR CELL TO 0.5 PSI BY APPLYING PRESSURE WITH NITROGEN SO THAT IT TAKE IT SHAPE.
4. CLOSE DRAIN VALVE & OPEN AIR RELEASE PLUG AFTER BREAKING VACUUM, OIL CAN BE FILLED THROUGH VALVE
(DRAIN VALVE,SHUT OFF VALVE FOR GOR) FROM MAIN TANK . LIMIT FILLING RATE TO MAX. OF 2000LT/HOUR. CONTINUE FILLING TILL OIL COMES OUT FREELY THROUGH AIR RELEASE PLUG.
5. NOW CLOSE AIR RELEASE PLUGS & CONTINUE FILLING TILL OIL COMES OUT FREELY THROUGH AIR VENT. CLOSE AIR VENT NOW RELEASE THE AIR PRESSURE HELD INSIDE AIRCELL & CONNECT AIRCELL TO BREATHER.
6. DRAIN OIL FROM CONSERVATOR BY GRAVITY THROUGH CONS. DRAIN VALVE OR THROUGH TRANSFORMER TILL MOG READING SHOWS LEVEL 3.

PRECAUTION:—

1.DURING OIL FILLING, PRESSURE INSIDE AIR CELL SHOULD NOT EXCEED 1.5 PSI
2 . DO NOT WELD ON CONSERVATOR TO AVOID DAMAGE TO AIRCELL.
3 . IF PRESSURE OR VACUUM IS APPLIED TO MAIN TANK CONSERVATOR MUST BE DISCONNECTED AND BLANKED AT SHUT OFF VALVE .

7.9 Buchholz Relay:

Note details of “Buchholz Relay” in the Commissioning Report for the transformer and of “Oil Surge Relay” for the OLTC in the “Commissioning Report”. Buchholz Relay floats are tied to prevent transit damages. They should be released. Also if ‘Test’ Lever is provided, It should being working position. Mount the “Buchholz Relay” and the shut off valves.

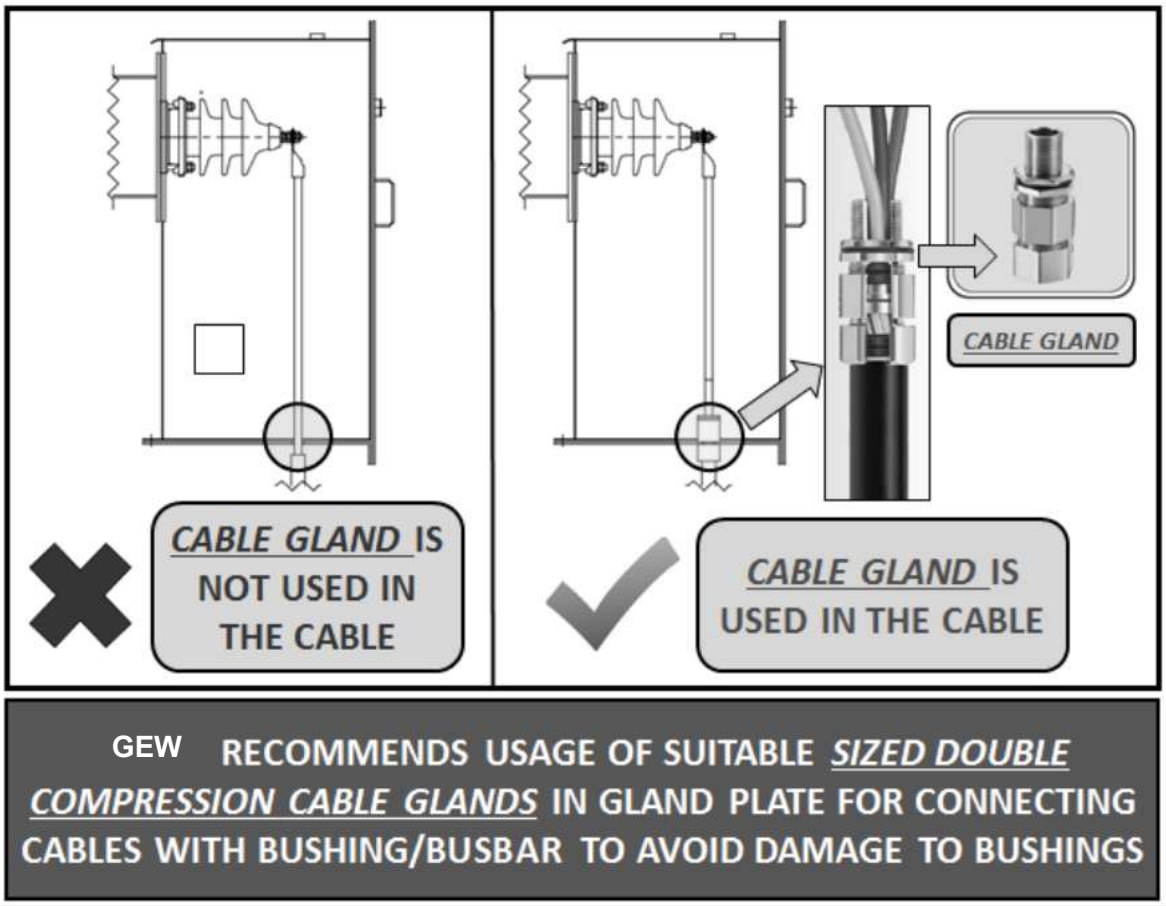
Similarly mount “Oil Surge Relay”. Both the relays to be mounted showing direction of arrow towards conservator side.

7.10 Breathers:

Note detail of Breathers, in the “Commissioning Report” if OLTC is provided, it may have its own separate breather. Note details of this Breather also in the “Commissioning Report”. Check that the color of Silica Gel in Main Breather is Blue. Remove the rubber cap closing the breather pipe and fit the breather. Fill oil in the oil cup up to the filling level and remove the seal, which closes the breather opening, similarly mount, the OLTC manner.

7.11 Cable Box:

When Cable Boxes are provided they should be mounted and cable terminations done as shown in drawing. Compound filled cable-boxes should be duly filled with compound. In case of “Bus-Duct” connections, transformer is provided with a flange to receive bus-duct. Duct connection and fitting should be done to overhead line by a terminal connector.



Caution: Cable gland must be used in cable box to avoid excess load and oil leakage from bushings.

7.12 Explosion Vent (If Applicable)

Remove the temporary plate provided on the transformer tank carefully to ensure that no loose parts fall inside the tank.

Check whether inside of vent is free from moisture, dust and rust.

Check whether the diaphragms are intact.

Lay the diaphragm such a way that the diaphragm should be in between two gaskets.

Assemble the pipe with care to avoid any cracking of the diaphragm and clamp with nuts and washers.

Fix the pressure equalizer pipe between the conservator and vent pipe if applicable.

7.13 Pressure Relief Device / Valve

Pressure relive valves are removed for transport if it is provided in the cover.

Examine the value for damages if any, before mounting and check the continuity with multi meter. The flag operation should be checked manually be lifting the switch operating rod.

Use gaskets supplied along with valve and the valve should be cleaned with compressed air.

Lay the gasket and locate the valve properly.

All the bolts should be tightened evenly so that the pressure is exerted on gasket and base.

Note: Please ensure to remove the full blank gasket (if provided) before oil Circulation / charging of transformer.

7.14 (a) Oil Sampling & Filtration (For Transformer and OLTC):

Taking usual precautions, draw oil samples from Bottom & Top of main tank and from OLTC. They should be tested for BDV. If they meet the requirements of I.S. 1866 for new transformers, no further processing is required. However if they do not meet the requirements, oil needs to be filtered till the required BDV is obtained.

(b) Oil Filtration (For Oil Drums):

Oil filtration for oil drums to be done separately and BDV to be check before filling in the transformer. If Oil meets the requirements of I.S. 1866 for new transformers, no further processing is required. However if they do not meet the requirements, oil needs to be filtered till the required BDV is obtained.

7.15 Thermo syphon Filter:

Assembly of thermo syphon filter consists of a steel container containing perforated steel trays. These trays are so arranged that there will be effective circulation of oil through proper contact with Alumina. This assembly is mounted on transformer connected with pipes and shut of valves as shown.

In General Thermo syphon are dispatched from factory after all necessary assembly. However if the same is received in unassembled condition, following procedure to be followed:

- Check that dried alumina is filled in trays
- Complete the assembly and piping
- Open the bottom shut off valves on transformer
- Release air through plugs at the top of filter
- Open the shut off valves on transformer
- Top up main conservator with transformer oil to required level.

7.16 Air Release:

Release air by slowly unscrewing Air Release Plug provided at Bushings, Bushing Pockets, Buchholz Relay, Main Tank Cover, and Oil Surge Relay etc. From Plain porcelain bushing of 11, 22 & 33 KV, air can be released by loosening the nut pressing the rubber gasket and pressing the metal part down.

7.17 Exposure time in Ester oil filling after Installation/ Assembly work:

- If there is any Installation/ Assembly work in the active part or bushing mounting at site, the exposure time needs to reduce. Do not open all the opening/ turrets at the same time. During Condenser bushing installation, open only required turret at a time to avoid exposure of active part. It is recommended to assembly should be completed in not more than 3 hrs. (Per bushing).
- After installation, perform the cross filtration (as per clause 9.2.o) to achieve required BDV and moisture contents of the Ester/ Mineral oil.

Caution: Special Care to be taken while handling of Ester Oil.

7.18 Leak test on erected transformer after oil filling

1. The air cell (if applicable) in main tank conservator shall be pressurized slowly by filling dry air or nitrogen gas to positive pressure as mentioned in COPS Instruction Plate.
2. After maintaining the test pressure (5 PSI measured at top cover of main tank) in transformer for 8 hours, all welded and oil gasket joints shall be visually inspected for any leakage of oil.
3. On completion of the inspection, dry air or nitrogen shall be released from the air cell and breather shall be connected to it through the breather pipe.
4. Oil level shall be adjusted appropriately after the leak test.

Note: 1. Hourly record to be maintain for the leak test conducted on erected transformer after oil filing.
2. Leak test on the pipes assembly done for the NIFPS (if required), shall be conduct as per NIFPS Vendor recommendation and record to be maintain.

8. COMMISSIONING

8.1 Operational system tests

Once the transformer has been (re-)checked and (re-)tested, some operational tests on the complete system - transformer, network and remote control facilities - are required.

Below instructions are meant as a general guideline. For more information, refer to the *General Arrangement Drawing*, the Nameplate, Schematic Drawings and documentation included in this OEM-manual. Also use the information about the network configuration, remote control and protection system.

Write down the test results on a copy of the “Site commissioning report” section.

8.2 Alarm circuits and contacts

Alarms are mentioned as a *warning for an abnormal situation* on the transformer or its accessories that needs observation, action and follow up. There is no need to place the transformer out of service.

The most commonly used alarms are:

- Slow gas production (Buchholz or gas relay).
- Temperature alarms (first stage oil and/or winding temperature).
- Oil level alarms (low and/or high level).

- Internal pressure alarms.
- Alarms on the cooling circuits (supply failures, oil flow failures, etc.).
- OLTC alarms (supply failures, etc.).

Please consult also the Nameplate and Schematic drawings in the drawing section.

If an alarm is generated on the transformer, *it should be checked if this alarm switches on the related alarms on the entire system* (such as signal lamps, flag relays, buzzers, remote indicators, etc.).

8.2.1 Trip circuits and contacts

Trip contacts on the transformer or on accessories *immediately place the transformer out of service* in any abnormal situation that can damage the equipment or its environment.

The most commonly used trip contacts are:

- Quick gas production (Buchholz or gas operated relay).
- Quick internal pressure rises.
- Network protection relays (fed by current and/or voltage transformers on the transformer).
- OLTC failure. etc.

If a trip is generated on the transformer, it should be checked if this trip immediately switches off the transformer from the network.

8.3 Remote control

Depending on the actual network control system, it should be checked that all functions work satisfactory both on the transformer (in the control cabinets) and in the remote control mode. The “Site commissioning report” is indicating both:

- MB.: Marshalling Box, FCC: Fan Control Cubicle or RTCC: Remote Tap changer Control Cubicle
- Client: All remote control equipment from the Client

8.4 Temperature settings

Make sure all temperature settings are correct and equal to or lower than the values on GEW drawings (Nameplate and/or Schematic drawings). Never use higher settings than the ones indicated on these drawings, as this can cause too slow reaction (or no reaction at all) of the protective devices. Needless to say that serious damage may occur.

CAUTION
Temperature Settings for OTI and WTI shall be as per requirement or as per GEW given drawings.

Carefully check the settings of:

- The thermostat(s)
- Oil Temperature Indicator(OTIs)
- Winding Temperature Indicators (WTIs) for the different windings

8.5 Verification of overpressure relief device

The same remarks apply as for the temperature settings.

8.6 PRE-COMMISSIONING CHECKS

a) Check the oil level in the conservators for transformer and tap changer, bushings.
b) Check the radiator valves, valves between conservators and main tank, valves between conservation and tap changer for opening.
c) Check for oil leakage in all gasket joints and any crack in bushings.
d) Release the trapped air in Radiators, Main tank, OLTC, Relays, Bushing turrets and bushings.
e) Check the alarm and trip contacts, annunciator windows, Hooters, Bell and tap position indicators.
f) Check the calibration of OTI & WTI.
g) Check the drain valve, filter valves, sampling valves for closing.
h) Check the transformer for proper earthing and neutral earthing.
i) Check for the locking of off circuit tap switch wheel at one tap setting.
j) Check the indication of the Magnetic oil level gauge.
k) Check whether the thermometer pockets filled with oil.
l) Check the external electrical connections.
m) Check the silica gel in the breather for its blue colour and oil level at the bottom cup.
n) Check the clamping of rollers.
o) Check the HRC fuse rating.
p) Check for any tools lying above the transformers.
q) Check the diaphragm in the explosion vent for damage.
r) Check the protection circuits.
s) Check the arcing horns gaps on bushings.
t) CT secondary should be shorted if not in use.
u) If any painting peels off, touching up can be done after erection.

8.6.1 Pre-Commissioning Check Points Record:

(Fill this format before commissioning and tick mark whichever is applicable, NA stands for not applicable)

Sr. No	Check Point	Tick appropriate
1	Oil Samples from main tank and O.L.T.C. passed BDV requirement.	Yes/No/NA
2	Bushing surfaces are cleaned.	Yes/No/NA
3	Test Tap Caps are fully tightened	Yes/No/NA
4	Oil Level in main conservator up to mark	Yes/No/NA
5	Oil level in OLTC Conservator (separate or compartment in main conservator) is up to the mark.	Yes/No/NA
6	M.O.G. lock is released	Yes/No/NA
7	Buchholz Relay lock is released	Yes/No/NA
8	Buchholz Relay Test Lever kept in S position	Yes/No/NA

9	Buchholz Relay shut off valves on Both sides are open	Yes/No/NA
10	Air Release valve of Buchholz Relay is closed	Yes/No/NA
11	Buchholz Relay arrowhead is Pointing towards conservator.	Yes/No/NA
12	Lock of Oil Surge Relay (OSR) on O.L.T.C. is released.	Yes/No/NA
13	OSR shut-off valve is open.	Yes/No/NA
14	OSR arrowhead is pointing towards conservator	Yes/No/NA
15	Color of Silica Gel in main breather is blue	Yes/No/NA
16	Oil is filled in main Breather up to level mark	Yes/No/NA
17	Sealing Tape of main Breather is removed.	Yes/No/NA
18	Color of Silica Gel in O.L.T.C breather is blue	Yes/No/NA
19	Oil is filled in O.L.T.C. breather up to level Mark	Yes/No/NA
20	Sealing Tape of O.L.T.C. breather is removed	Yes/No/NA
21	All radiator Valves-Top and bottom are open.	Yes/No/NA
22	Valve connecting Main Tank to Cable Box is open.	Yes/No/NA
23	Oil is filled in Disconnecting Cable Box up to level mark	Yes/No/NA
24	All sampling, drain and filtration valves are closed.	Yes/No/NA
25	Oil filling cap on main conservator is duly filled.	Yes/No/NA
26	There is no oil leakage from anywhere.	Yes/No/NA
27	Explosion Vent diaphragms are intact and there is no oil in explosion vent.	Yes/No/NA
28	Oil is filled in O.T.I./W.T.I. pockets	Yes/No/NA
29	Air released from	
i	All Bushings.	Yes/No/NA
ii	All Bushing Pockets.	Yes/No/NA
iii	Buchholz Relay	Yes/No/NA
iv	Main. Tank Cover.	Yes/No/NA
v	All radiators.	Yes/No/NA
vi	OSR on O.L.T.C.	Yes/No/NA

vii	O.L.T.C. Tank cover.	Yes/No/NA
30	O.L.T.C. / Off Circuit Tap Switch is in the desired position and is properly locked.	Yes/No/NA
31	Tank earthing and tightening is done (paint to be remove from earthing pads if required).	Yes/No/NA
32	Neutral earthing is duly done.	Yes/No/NA
33	Rollers are locked.	Yes/No/NA
34	C.T. secondary terminals, if not wired, are shorted and earthed.	Yes/No/NA
35	Alarm & Trip contacts of O.T.I. & W.T.I. are set	Yes/No/NA
36	External connections are duly tightened.	Yes/No/NA
37	Full Blank gasket removed from PRV (if provided)	Yes/No/NA
38	Do's and Don'ts followed for Cable boxes (as per 7.11)	Yes/No/NA

8.7 PRE - COMMISSIONING TESTS:

Prior to energizing the transformer, several pre-commissioning tests are to be performed. The objective of these tests is to confirm that the transformer has not suffered damage during transit, for maintenance purpose, and in future comparison if the transformer gets mal functioning.

8.7.1 BREAKDOWN VOLTAGE OF OIL

a) **PURPOSE**: To confirm the dielectric strength of oil as per recommended IS.

b) **SCOPE**: Applicable to all Oil Filled Transformers.

c) **PROCEDURE:**

1 The samples can be taken only after settling of oil. The sample valves and the container used for sampling should be free from moisture.

2 Glass bottles with stoppers can be used for sampling so that the water contents present in the oil will settle at the bottom which can be easily visible.

3 The oil samples taken from main tank, OLTC, and drums should be tested as per IS 335 / BS 148.

4 While testing BDV of oil should be as per IS 10028, if not filtration to be done to achieve the minimum Break Down Value of oil (BDV) as per standards.

5 Oil should be tested six times by using the same container and value will be calculated as arithmetic mean of the above.

6 As water and water mixed in the oil are both heavier than the dry oil and sink to the bottom of the container. Therefore samples should be taken at the bottom of the tank only.

7 In case of drum, after keeping the drum vertically upwards for 24 hours the samples can be taken. A clean glass or brass tube long enough to reach within 12 mm of the lowest part of the drum can be used for sampling.

i. **ACCEPTANCE CRITERIA**

Arithmetic average (six readings) of break down voltage of oil should be greater than 60 KV RMS.

e) PRECAUTIONS

1. Gap between electrodes to give mentioned as required. (2.5 mm No go)
2. Sampling collection should not contain any impurities.
3. At least give 5 minutes duration among readings.

a. RECORDS: Oil Test Results:

(Details of Oil Test Set), Make: Type: Motorized / Manual,

Gap : 2.5 mm (no go)

Observed BDV:

(a) Main Tank Oil : Before Filtration :
: After Filtration :

(b) O.L.T.C. Oil : Before Filtration :
: After Filtration :

8.7.2 RATIO TEST (VOLTAGE METHOD) & MAGNETIZING CURRENT MEASUREMENT

a) PURPOSE: To conform constant output voltage on L.V. winding at all tap positions.

b) SCOPE: This test procedure is applicable to any transformer whose voltage ratio (H.V phase voltage / L.V. phase Voltage) at any tap position should be greater than one.

c) PROCEDURE: -

(i) The ratio should be checked at all positions and all phases usually by applying voltage of 415 volts approximately.

(ii) Voltage to be applied on H.V. winding by phase-wise (for phase starting and finishing leads please refer to connection diagram or R & D plate diagram on transformer) and arrange the circuit as shown in diagram-1 (shown for delta-star Dyn11)

(iii) If transformer is off-circuit then during changing tap position cut off the H.V. supply.

(iv) For transformer with O.L.T.C. during tap changing, supply need not to be interrupted.

(v) Record the reading as shown in format. (Attached)

(vi) H.V. voltmeter, ammeter & L.V. voltmeter readings to be taken instantaneously.

d) ACCEPTANCE CRITERIA: -

(i) The measured voltages on L.V. phase shall confirm to increasing trend between highest voltage tap positions to lowest voltage tap position for all phases. (Considering applied voltage remain constant)

(ii) Magnetizing current measured on H.V. side shall confirm to increasing trend between highest voltage tap position to lowest voltage tap position for all phases. (Considering applied voltage remains constant).

e) PRECAUTION: -

(i) On H.V. low range AC. ammeter is to be connected.

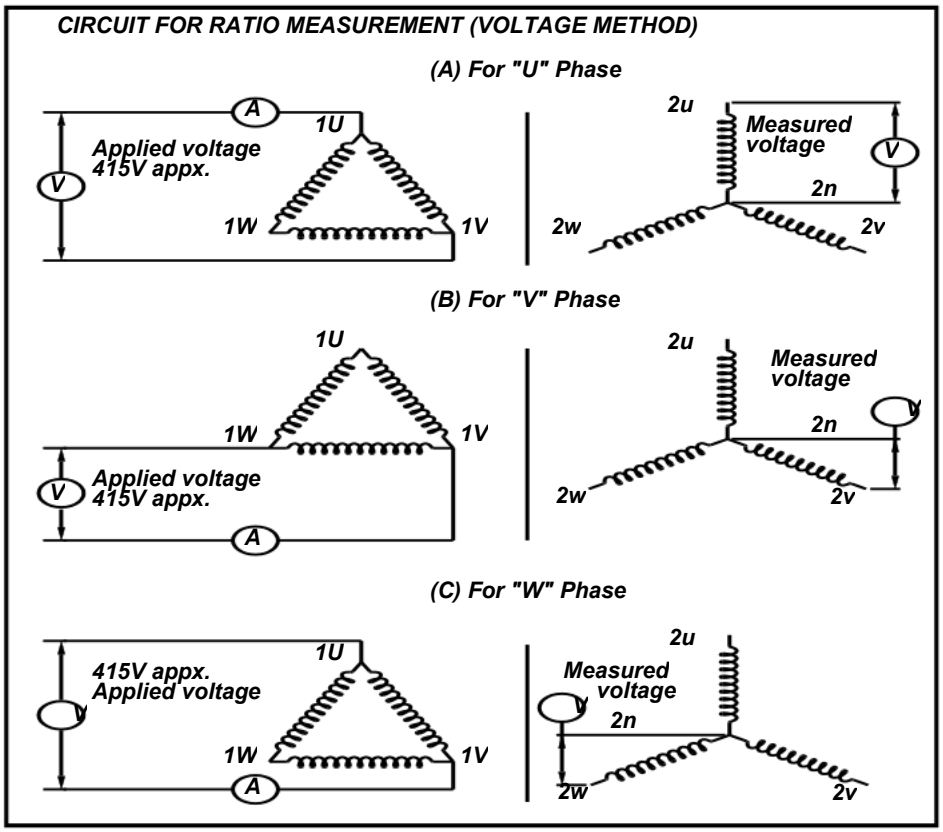
(ii) H.V. and L.V. readings to be recorded instantaneously.

(iii) Suitable fuses or tripping arrangement to be provided on H.V. side before starting test.

(iv) Preferable accuracy of meters required 0.5 class and range should be selected such that measured readings should be more than 50% of full scale.

f) RECORD:

TAP NO	APPLIED VOLTS (V) on HV	AMP (A)	MEASURED VOLTS (V)	APPLIED VOLTS (V) on HV	AMP (A)	MEASURED VOLTS (V)	APPLIED VOLTS (V) on HV	AMP (A)	MEASURED VOLTS (V)	1U1V / 2Un	1V1W / 2Vn	1W1U/ 2Wn	ACUTAL RATIO
	U PHASE			V PHASE			W PHASE			Calculated Ratio			
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													



Above Circuit Diagram is for reference purpose only.

8.7.3 INSULATION RESISTANCE MEASUREMENT

a) PURPOSE: To measure the insulation resistance between windings and windings to earth / tank.

b) SCOPE: Applicable to all transformers.

c) PROCEDURE: -

(i) Insulation resistance to be measured between H.V. winding to L.V. winding, H.V. winding to tank/earth, L.V. winding to tank / earth.

(ii) Arrange the circuit as shown in figure.

(iii) Use the motorized or hand driven megger, output voltage should be more than 1000 volts.

(iv) If it is hand driven megger than it has to be rotated with constant speed for 60 seconds.

(v) Record the reading at 60^{th} and 600^{th} seconds in as shown below table format.

d) ACCEPTANCE: -

INSULATION RESISTANCE Value at ambient temperature (for mineral oil)

Voltage Class	Min. IR value in (Mohm) at 60sec.
Up to 3.3kV	250 MΩ
3.3kV to 6.6kV	400 MΩ
6.6kV to 11kV	450 MΩ
11kV to 33kV	600 MΩ
33kV to 66kV	1000 MΩ
66kV to 132kV	2000 MΩ

e) PRECAUTIONS: -

(i) Ensure the discharge of the windings after each measurement.

(ii) Transformer tank to be grounded.

(iii) For 1.1kV voltage class winding Megger voltage should not be more than 2500v.

f) RECORDS:

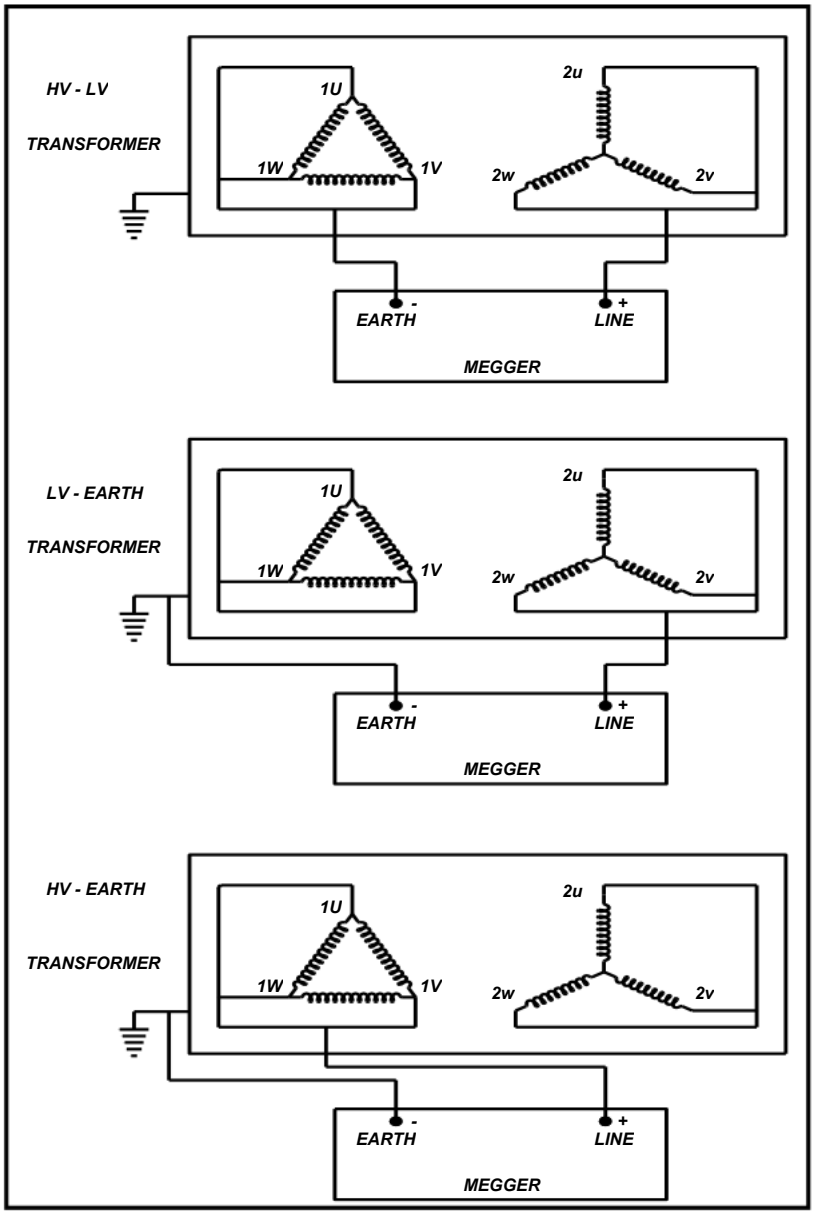
MODE	VOLTAGE (V)	IR VALUE IN MΩ AT		POLARISATION INDEX (PI) (IR at 600^{th} sec / IR at 60^{th} sec)	OIL. TEMP °C
		60th SEC	600th SEC		
H.V. / L.V.					
H.V. / EARTH					
L.V. / EARTH					

Core-Frame (if terminals provided):…….

Core to Tank (if terminals provided):……

Frame to Tank (if terminals provided/applicable):…….

INSULATION RESISTANCE MEASUREMENT



Above Circuit Diagram is for reference purpose only.

8.7.4. MAGNETIC BALANCE TEST

a) PURPOSE: Preliminary check to confirm the healthiness of windings.

b) SCOPE:

(i) Can be performed on any transformer from HV side.

(ii) Can be performed from LV side also for transformer having LV voltage more than 3.3 KV.

(iii) Application for core type transformer.

c) PROCEDURE: -

(i) Test to be carried by applying 415 volts on HV winding phase wise (for starting and finishing leads refer to connection or R & D diagram fixed on transformer).

(ii) Apply the voltage on one phase and measure the voltage on other two phases and record the readings as shown format.

(iii) When Neutral is available on HV apply voltage between neutral and phase.

d) ACCEPTANCE: -

(i) When voltage is applied on *U-Phase, V-Phase should read 60% to 80% of applied voltage and W-Phase to read 40% to 20% of applied voltage.

(ii) When voltage applied on *V-Phase, U-Phase and W-Phase should read 40% to 60% of applied voltage.

e) PRECAUTIONS: -

(i) Other windings of the transformer should be open.

(ii) To be performed before subjected to and direct voltage / current tests.

(iii) Stay away from the HV terminal while doing test from LV side.

f) RECORDS: - (*) → APPLIED VOLTAGE

U-PHASE	V-PHASE	W-PHASE
*		
	*	
		*

8.7.5 LOAD BALANCE TEST

a) PURPOSE: To confirm the balancing of current in all three phases when transformer is fully loaded.

b) SCOPE: Applicable for all transformers.

c) PROCEDURE: -

(i) This test is to be conducted on each phase of transformer.

(ii) Arrange the circuit as shown in figure 4 (shown for Delta-Star transformer).

(iii) Apply the voltage preferably on H.V. winding (refer R & D or connection drawing for start and finish leads of winding).

(iv) Record the values of voltage, current of H.V. and current of L.V. windings instantaneously.

(v) This test can be performed at all tap positions.

(vi) For off-circuit transformers before tap changing supply to be disconnected.

d) ACCEPTANCE: Considering applied voltage constant on H.V. the ammeter reading of all three phases should be within 2 to 5% variation.

e) PRECAUTIONS: -

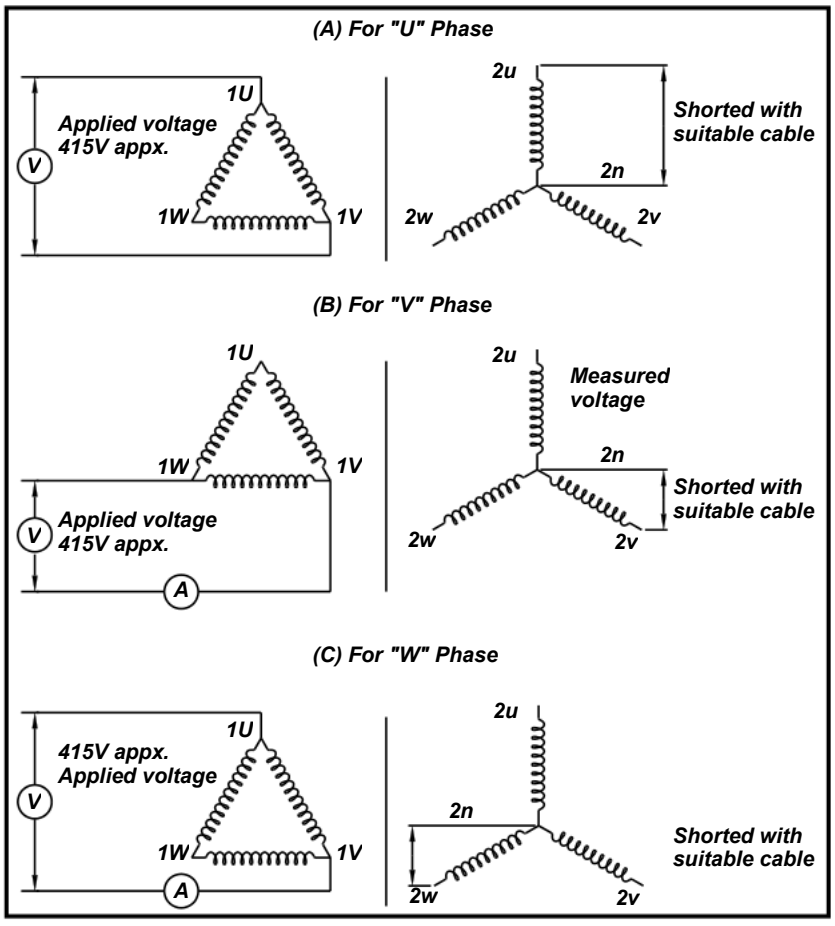
(i) Ensure the shorting of secondary terminals of all C.T.'s in transformer before starting the test.

(ii) Calculate approximate current drawn by HV and LV windings at applied voltage based on % impedance punched on R & D diagram.

(iii) Use suitable cross section of copper cables such that current density should not exceed 2.5A/sqmm.

(iv) Preferable accuracy of meters required 0.5 class and range should be selected such that measured readings should be more than 50% of full scale.

CIRCUIT DIAGRAM FOR LOAD BALANCE TEST



Above Circuit Diagram is for reference purpose only.

f) RECORDS:

TAP NO	APPLIED VOLTS (V) on HV	AMP (A) HV	MEASURED AMPS LV	APPLIED VOLTS (V) on HV	AMP (A) on HV	MEASURED AMPS LV	APPLIED VOLTS (V) on HV	AMP (A) on HV	MEASURED AMPS LV
	U PHASE			V PHASE			W PHASE		
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
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20									
21									

8.7.6 VECTOR GROUP

a) PURPOSE: To verify the polarity and phase relationship of HV and LV connections.

b) SCOPE:

(i) This procedure is applicable to all vector groups on defined conditions from vector diagram.

(ii) Conditions are defined for few vector groups like Dyn11, Dyn5, Dyn1, Ynd1, Ynd11, Ynyn0, Ynyn6, and Dd0.

c) PROCEDURE:

(i) Short the terminals 1U, 2U.

(ii) Apply three-phase supply on 1U, 1V, 1W.

(iii) Measure the voltage between following terminals and record them.

(iv) Verify the condition as shown in vector diagram in figure (2)

Voltage between: -

1 U - 1 V =

1 V - 1 W =

1 U - 1 W =

1 V - 2 v =

1 V - 2 w =

1 W - 2 w =

1 W - 2 v =

d) ACCEPTANCE: -

Condition to be satisfied as shown in vector diagram in figure 2.

e) PRECAUTIONS: -

(i) Neutral terminal should be in floating condition.

(ii) Make sure that 3-phase supply connected to HV winding only.

(iii) 1U - 2U terminal to be shorted with insulated wire.

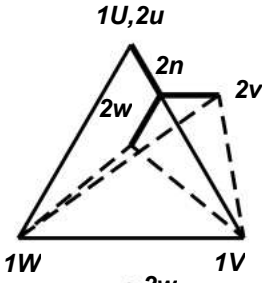
f) RECORDS: MEASURED VOLTAGES BETWEEN:

1 U - 1 V =	
1 V - 1 W =	
1 U - 1 w =	
1 V - 2 v =	
1 V - 2 w =	
1 W - 2 w =	
1 W - 2 v =	

CONDITIONS ARE VERIFIED AS PER VECTOR DIAGRAM, FOUND OK.

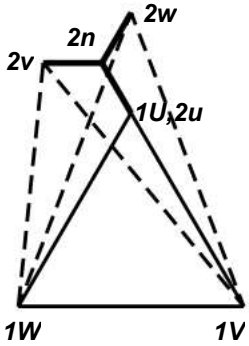
(A) Dyn11

CONDITION TO BE SATISFIED
1V - 2v = 1V - 2w
1W - 2V >1W -2w



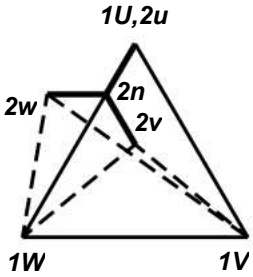
(B) Dyn5

CONDITION TO BE SATISFIED
1W - 2w = 1W - 2v
1v - 2w >1W -2v



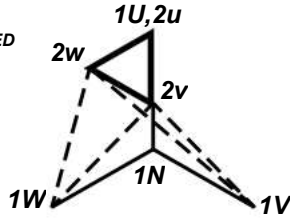
(C) Dyn1

CONDITION TO BE SATISFIED
1W - 2w = 1W - 2v
1v - 2w >1V -2v



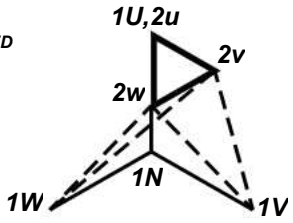
(D) Ynd1

CONDITION TO BE SATISFIED
1W - 2v = 1V - 2v
1v - 2w >1W -2w



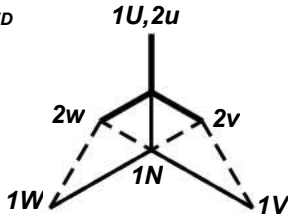
(E) Ynd11

CONDITION TO BE SATISFIED
1W - 2w = 1V - 2w
1W - 2v >1V -2v



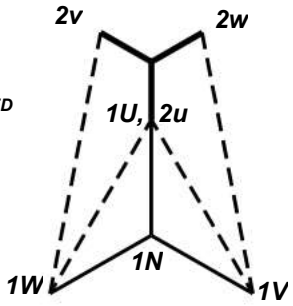
(F) Ynd11

CONDITION TO BE SATISFIED
1W - 2w = 1V - 2v
1W - 2v =1V -2w



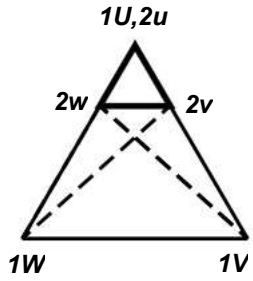
(G) Ynyn6

CONDITION TO BE SATISFIED
1W - 2v = 1V - 2w
1W - 2u =1V -2u



(H) Dd0

CONDITION TO BE SATISFIED
1V - 2w = 1W - 2v
1W - 2w =1V -2v



8.8 Voltage relation check

a) Before switching on, a final check of the voltage relation between all incoming and outgoing voltages should be performed.

b) All Protection instruments like Overcurrent relay, Differential relay , Overvoltage relay Annunciator alarming etc. are as per current /voltage rating of transformer and are in working condition.

8.9 Energising

Once the transformer is fully assembled, checked and tested as described above, and after final checks and testing of the protection equipment, reports to be shared with manufacturer for getting the charging Clearance from the Manufacturer.

⚠ **It is mandatory to get the Charging Clearance from the Manufacturer before energizing the transformer.**

A) First energizing at no load conditions.

Set the OLTC/OCTC for the right voltage ratio. Lock the OCTC handle against mal-operation while the transformer is off circuit.
To reduce the inrush-current during the first energizing, it is advisable to set the OLTC two or three steps out of the voltage ratio, so that more turns are in service (refer to the Nameplate). This can only be done if the transformer is of a variable flux design.
1. Switch on the voltage
2. Check the secondary voltage (and eventually the tertiary voltage).
3. Check the no load current.

Note: During the first energizing, a noise-peak can be detected. This peak will disappear after a few minutes up to an hour.

A general observation of and around the equipment is suggested and should include a general awareness of what is happening to all the equipment located in the electrical substation.

Unusual noises and disturbances should be investigated such as:

- Fans, pumps, etc. operating when they should not
- Circuit breakers or other equipment operating at odd moments.
- OLTC taps changes too frequent or no changes at all.
- Oil leaks. Small quantities of oil can spread over large areas and can collect a lot of dust very quickly.

B) Loading the transformer

DANGER: Always put transformer on Load after 24 hours of charging at no load condition.

Set the OLTC in the right position and check the outgoing voltage. (If parallel-operation with other transformers is provided, the voltage ratio should be the same for all transformers). If an AVR (automatic voltage regulator) is provided, the tap changer will automatically run to the right position.
1. Switch on the load
2. Check and record the following:
    - Voltages and load currents
    - Ambient temperature, oil and winding temperatures and oil level(s).

Condition of accessories (as dehydrating breathers, fans, pumps etc...)

9. MAINTENANCE AND MAINTENANCE SCHEDULE

NOTE: This activity should be performed by qualified person having required knowledge about maintenance of transformers / electrical equipment generating high voltages.

9.1 General:

If a transformer is to give long and trouble free service, it should receive a reasonable amount of attention and maintenance. Maintenance consists of regular inspections, testing and reconditioning where necessary. Records should be kept giving details of any unusual occurrence and also of any previous results taken.

The principal object of maintenance is to maintain the insulation in good condition. Moisture dirt and excessive heat in contact with oxygen are the main causes of insulation deterioration and avoidance of these will in general, keep the insulation in good condition Factors lead to aging of insulation during the aging process, are due to chemical and physical effects. The decay of the insulation follows the chemical reaction rate. In case of oil immersed transformers, if the sustained operating temperature of 75C is higher by 6 deg. C to 10 deg. C it will reduce the life of the transformer. Following are the factors affecting the life of transformer.

a) Moisture:

Due to higher affinity of water, the transformer oil and the insulation paper absorb moisture from the air, which results in decrease of dielectric strength. Hence preventive steps should be taken to guard against moisture penetration to the inside of the transformer. This will include blocking of all openings for free access of air in storage and frequent reactivation of breathers in service.

b) Oxygen:

Oxygen may be present inside the transformer oil due to air pockets trapped in the windings, etc. The oxygen reacts on the cellulose of the insulation and decomposes it, which will result in sludge formation, blocking free circulation of oil. Sometimes, the oxygen may act as catalytic agent and increase the operating temperature between hot oil and bare copper.

c) Solid impurities:

Dielectric strength of oil diminishes appreciably by minute quantities of Solid impurities. It is therefore a good practice to filter the oil after it has been in service for a reasonable time.

d) Varnishes:

Some varnishes particularly of the oxidizing type enter readily in reaction with transformer oil and precipitate sludge on the windings. Synthetic varnishes having acid-inhibiting properties generally delay the natural formation of acid and sludge in the oil. This should be borne in mind by the maintenance engineer when rewinding and replacing the coils during repairs of transformers.

e) Effects of slackness of windings:

Coils are fully clamped before the transformer leaves the factory. Natural setting of coils may take place during first few months of operation. Slackness of winding may cause a failure due to repeated movement of coils which may wear the conductor insulation at some places and lead to an inter turn failure. The coils may also get displaced under the load conditions or momentary short circuit, which may cause electric and magnetic unbalance. It is therefore a good practice to lift the core and windings of a transformer and remove any slackness by tightening the tie rods or pressure screws.

9.2 Maintenance Procedure:

(a) No work should be done on the transformer unless it is disconnected from all external electrical circuits and all windings have been solidly earthed.

General notes on information given under storage, handling and installation are applicable for routine maintenance. Oil level shall be maintained to keep all insulation under oil and lowered to reasonable level before slackening and removing bolts, nuts on tank conservator, radiators, etc.

No fire shall be near the transformer while work is going on. Precautions are to be taken to secure tools with tape outside the tank, to prevent them from dropping inside the tank.

(b) Core and winding: It is recommended that the core and windings be removed from the tank for visual inspection as per the maintenance schedule at the end. The windings should be examined to ensure that no sludge has been deposited blocking the oil ducts. Any loose nut and bolt should be tightened.

Adjusting tie rods / coil clamping screws provided should be tightened to bear evenly and firmly on the coil clamping blocks / rings, if there is any slacking of windings.

Before lifting the core and windings from the tanks it is necessary to disconnect the windings from the bushings inside the tank, to disconnect the off circuit tap switch handle, to remove earthing strip between the core and the tank, and remove fixing bars between core clamps and tanks guide bars.

The core and windings must be removed with great care under cover and in dry place. If this is not possible, a visual inspection of as much of the transformer as can be seen within its tanks should be carried out. Refer untanking instruction also.

(c) Off circuit tap switch:

(i) This is an integral part of the transformer. Care should be taken to switch off the transformer from line before operating the switch handle. To operate the switch, unlock the operating handle by removing the locking strip / pin. Move the handle tie required position and relock. Tapping position number can be seen through the window of handle alternatively on the handle when window not provided.

(ii) On load tap changer:

On load tap changer is normally mounted on the tank in a separate housing and connected to winding leads through copper studs fixed on an insulated terminal board. Terminal board is oil leak proof. Oil in the tank need not be lowered down for attending to OLTC gear. Please see OLTC leaflet for the operation and maintenance instruction.

(d) Conservator:

Conservator is so designed that the lower part acts as sump in which any impurities entering the conservator will collect. A drain plug is fitted at the lowest point or the conservator for draining and sampling oil. While sampling care must be taken to run off any contaminated oil before taking a sample for testing. The inside of the conservator should be cleaned every 2 or 3 years by flushing clean transformer oil to remove sludge and other impurities. Oil level should be maintained at “Filling level” mark (+30 C).

(e) Oil gauges:

Plain oil gauge: Oil gauge glass should be kept clean so that the gauges can fulfill their purpose Broken glasses should be replaced immediately.

Magnetic oil gauge: When the conservator is stripped for cleaning, the mechanism of the float type oil gauge should be inspected and cleaned. The function of alarm and trip contacts should be checked.

(f) Silica gel dehydrating breather:

Breather should be examined frequently to ascertain if the silica gel requires changing. The frequency of inspection depends on local climate and operating conditions. More frequent inspections are needed when the climate is humid and when transformer is subjected to fluctuating load. The crystals of silica gel in the breather act as an indicator and changes from blue to pink, on becoming saturated with moisture. When majority of crystals have turned pink, the silica gel should be heated in oven or a shallow pan at a temperature of 150C to 200C until the original blue color is regained.

This usually takes 2 to 3 hours. Oil should be cleaned to remove dust and dirty oil. The level in oil seal should be maintained with fresh oil. Check that inside of connecting pipe between breather and conservator is clean and not rusted. If necessary clean and paint inside with oil resistance paint.

(g) Buchholz relay:

Routine operation and mechanical inspection tests should be carried out at one or two yearly intervals respectively. The operation is tested by injecting air through lower level petcock of double float buchholz relay. (Refer installation manual of buchholz relay for testing). After inspection, any air, which has accumulated in the gas chamber full of oil.

To carry out mechanical inspection, the oil level should first be brought below the level of relay or the shut off valve between conservator and tank closed and the mechanism removed. The float should be tightly clamped and be in good order. If a mercury switch is defective owing to the glass being cracked, there will be clouding of the glass. In such cases the switch must be replaced.

During operation if there is an alarm and gas is found to be collected, the transformer should be isolated from lines and gas should be tested and analyzed to find out the nature of fault. Sometimes it may be noticed that the gas collected is only air. The reason for this may be that the oil is releasing any absorbed air due to change in temperature. Internal faults can be identified to a great extent by a chemical analysis of gas.

By examining the gas it is possible to detect the nature of fault.

(i) Colorless and odorless gas with faint odor of oil is air trapped in the oil or insulation.

(ii) Grayish white, non-inflammable gas with sharp penetrating odor may be due to the overheating or faulty insulation.

(iii) Yellowish and inflammable gas may be due to surface leakage on material like wood.

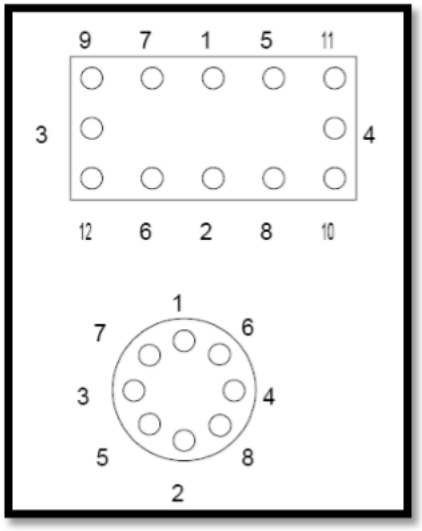
(iv) Dark gray and inflammable gas may be due to flashover in oil or due to excessive overheating of oil caused by a fault in the winding or core.

(h) Explosion vent:

The diaphragm, which is fitted at the exposed end of the vent should be inspected at frequent intervals and replaced if damaged. Failure to replace the diaphragm quickly may allow the ingress of moisture in the transformer. If the bottom diaphragm has broken because of a fault in the transformer, an inspection should be carried out to determine the nature and cause of the fault.

(i) Gaskets:

Gaskets sometimes shrink during service. It is therefore, necessary to check the tightness of all bolts / fasteners of gasket joints. The bolts should be tightened evenly around the joints to avoid uneven pressure (Refer below diagram for sequence). Leakage gaskets should be replaced as soon as the circumstance permit.



(j) Pipe work:

The pipe work should be inspected at least once a year. Leak may be due to badly sealed joints caused by misalignment, in which case the pipes should be aligned and joints remade.

(k) Temperature indicators:

At each yearly maintenance inspection, the level of oil in the pockets holding thermometer bulbs should be checked and the oil replenished if required. The capillary tubing should be fastened down again if it has become loose. Dial glasses should be kept clean and if broken, replaced as soon as possible to prevent damage to the instrument.

Temperature indicators, if found to be reading incorrectly, should be calibrated with standard thermometer immersed in hot oil bath.

(l) Paint work:

During storage and service, the paintwork should be inspected once a year and necessary painting or retouching carried out.

If the metal surface is exposed and becomes dirty, rusty or greasy because of delay in repairing the paint work, the surface must be thoroughly cleaned before repainting to ensure a good bond between metal and paint, If recommended paint are not available, any good quality synthetic enamel paint may be used.

(m) Untanking and tanking details:

General: For transformers assembled with bushings, conservator, pipe work etc.

Before removing the top cover from the tanks following care should be taken.

(i) All the bushing/cable boxes/pockets mounted on cover (connected to core and winding) should be mechanically disconnected off the transformer and removed carefully.

(ii) External cable connections lay over the cover connected to terminal box, buchholz relay, OTI, etc. should be disconnected and removed.

(iii) Thermometer bulbs along with capillary tubes to be removed.
(iv) Pipe work from the cover to the conservator to be removed, if conservator is separately supported on tank brackets.

(v) Oil should be drained out below the tank curb level.

(vi) All isolating valves should be closed.

(vii) Disconnect CT secondary leads connections when CT's are mounted on the live part.

(viii) Disconnect core and winding (live part) from all external connections, to avoid damages while removing cover from the tank.

(ix) Detach the fixing bolted to the square angular guide bars on the tank.

(x) Before lifting core and windings check that the lifters are rigidly fixed to core clamps.

(a) Untanking the core and windings of transformer with off circuit switch:

(i) Drain out oil below switch handle level from transformer tank.

(ii) It is important that the switch handle assembly should be dismantled before untanking the core and windings.

(b) Untanking of core and windings of transformer with OLTC:

(i) Drain out oil below the cover level of transformer and OLTC.

(ii) Detach the windings leads from the terminal board between transformer and OLTC.

(iii) Ensure that the lead number tags are in position on the leads. If not, tag the leads correctly to reconnect the leads in correct position on terminal board.

(iv) Give temporary support under the OLTC housing before lifting the core and windings from the tank. It is likely that the tank may become unstable due to weight of OLTC without core and windings in main tank.

(v) Refer OLTC leaflet for further information.

(n) Exposure time in Ester oil filling after Installation/ Assembly work:

- If there is any Installation/ Assembly work in the active part or bushing mounting at site, the exposure time needs to reduce. Do not open all the opening/ turrets at the same time. During Condenser bushing installation, open only required turret at a time to avoid exposure of active part. It is recommended to assembly should be completed in not more than 3 hrs. (Per bushing).

After installation, perform the cross filtration (as per clause 9.2.o) to achieve required BDV and moisture contents of the Ester/ Mineral oil.

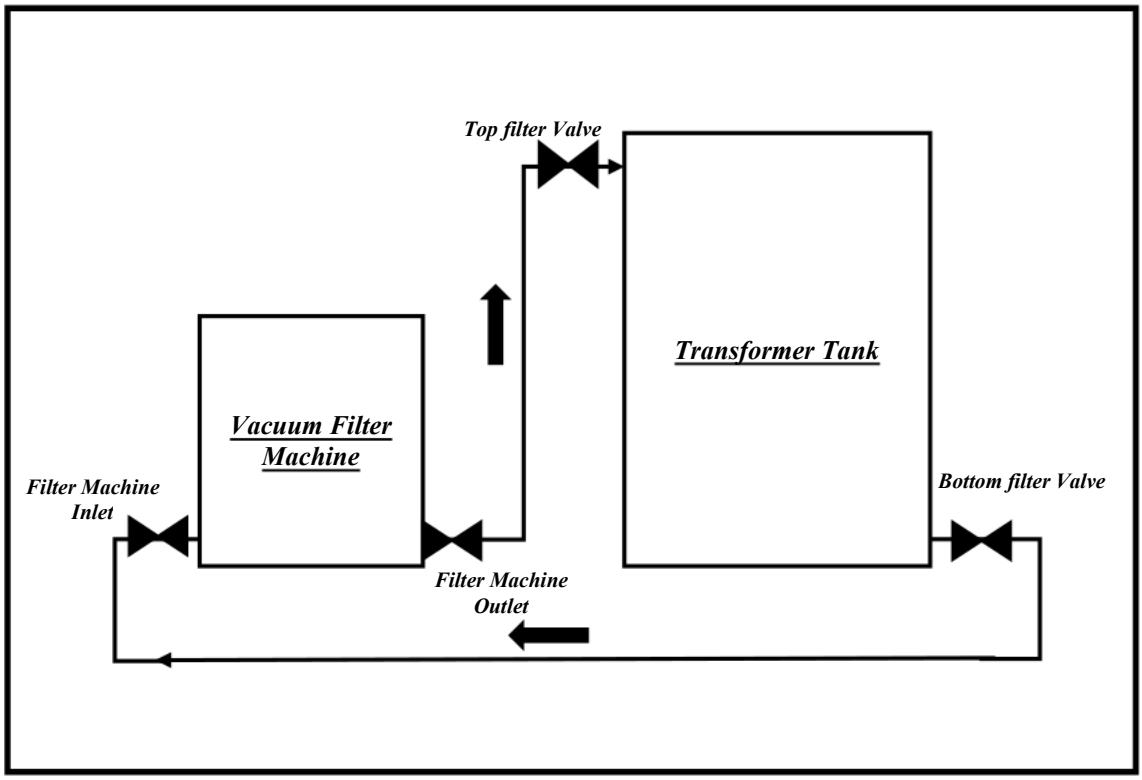
Caution: Special Care to be taken while handling of Ester Oil.

(o) Filtration of Oil:

Cross Filtration of oil is recommended only when breakdown voltage is less than 60kV (rms) and PPM value (for ester oil: 50-60ppm and for mineral oil: <15PPM) for voltage class up to 145kV.

Process:

1. Refer Outline General arrangement drawing for Top filter valve/ filling valve and bottom filter valve /drain valve provided on transformer main tank
   Do not use valves provided on the conservator for cross filtration
2. Flush the Filtration machine with the fresh oil. Most types of filtration machine used for mineral oil service can be used with ester oil. If existing filtration equipment is previously used for mineral oil, then residual mineral oil from filtration machine should be drained from heating chamber, dehydration chamber and filtration chamber and flushed with ester oil to minimize mineral oil content.
3. Maintain the temperature between 60-70 deg. C only.
4. Ester oil can tolerate much more water than conventional mineral oil before compromising its electrical characteristics. If moisture content of ester oil increases above acceptable limits, additional treatment is must.
5. It is highly recommended to check the PPM value especially with Ester oil along with break down voltage of oil.



Caution: 1. Special Care to be taken while handling of Ester Oil
2. Filtration machine should be clean/ flushed out every time when it is being used for filtration/ transfer of Oil (for both mineral oil as well as Ester oil) to avoid the mixing of two different oil in transformer.

9.3 Maintenance Schedule:

Sr. No.	Inspection Frequently	Items to be Inspected	Inspection Note	Action required. If inspection shows unsatisfactory conditions
(1)	(2)	(3)	(4)	(5)
1	Twice A day	Winding Temp.	Check that temp. rise is reasonable	Shut down the transformer & investigate if either is persistently higher than normal.
2	Twice A day	Oil Temp.	--DO--	--DO--
3	Twice A day	Load (Amperes)	Check against rated figure	Note: An improper tap position can cause excessive core loss.
4	Twice A day	Voltage	--DO--	--DO--
5	Daily	Oil level in transformer	Check against oil gauge	If low, examine the transformer for leak.
6	Daily	Relief vent diaphragm (if Used)		Replace if cracked or broken.
7	Daily	Dehydrating breather	Check colour of the active agent	If silica gel is pink change by spare charge. Oiled charge may be reactivated for further.
8	Quarterly	Bushing	Examine for crack and dirt deposits	Clean or replace.
9	Quarterly	Oil in transformer	Check the Electric strength and water content	Take suitable action to restore quality of oil.
10	Quarterly	Dehydrating breather	Check oil level in oil cap and that air passages are free	Make up oil, required.
11	Half yearly	External switch drive for off circuit switches	Operate 2 or 3 runs through complete range	Take suitable action.
12	Yearly or earlier if transformer can conveniently be taken out for checking	Oil in transformer	Check for acidity and sludge	Filter or replace.
13	Yearly or earlier if transformer can conveniently be taken out for checking	Insulation resistance	Compare with value at time of commissioning	Process if required.

14	Yearly or earlier if transformer can conveniently be taken out for checking	(i) Oil filled bushings (if Used) (ii) Oil flooded bushings (if Used) (iii) Cable boxes for (iv) Arcing horns	Test oil Check air-releasing arrgt. and oil leaks Check sealing arrangement for filling hole. Examine compound for cracks Examine for dirt deposits	Filter or replace. Clean holes in stem. Replace gaskets. Replace gaskets, if leaking. Clean.
15	Yearly or earlier if transformer can conveniently be taken out for checking	Gasket Joint	-	Tighten the bolts evenly to avoid uneven pres.
16	Yearly or earlier if transformer can conveniently be taken out for checking	Relays, alarms, their circuit, etc.	Examine relay and alarm contacts and their operation, fuses etc. check relay accuracy, etc.	Clean the components or replace contacts and fuses if necessary. Change the setting if necessary.
17	Yearly or earlier if transformer can conveniently be taken out for checking	Temperature indicator	Pockets holding thermometer should be checked	Oil to be replenished if required.
18	Yearly or earlier if transformer can conveniently be taken out for checking	Dial type oil gauge	Check pointer for freedom	Adjust if required.
19	Yearly or earlier if transformer can conveniently be taken out for checking	Earth resistance	-	Take suitable action, if resistance is high.
20	Yearly or earlier if transformer can conveniently be taken out for checking	Paint work	Should be inspected	Any painting or retouching should be done, if necessary.
21	Two - yearly	Oil conservator	Internal inspection	Should be thoroughly cleaned.
22	Two - yearly	Buchholz relay	Mechanical inspection	Adjust floats. Switches, etc. as required.
23	3 to 5 may be extended to 10 Years based on above inspection Observations	Complete transformer	Overall inspection including lifting of core and coils	Wash by hosing down with clean dry oil. Tighten where necessary.

10. TROUBLE SHOOTING

At the time of commissioning or periodic maintenance if any abnormalities are observed, corrective action should be taken immediately. Guidance for this is given in I.S. 10028 (Part III) Maintenance.

Following are the possibilities of malfunctioning which relates to the Electrical and Mechanical malfunctioning

A) Electrical Malfunctioning

Electrical malfunction, Observations made								
The power supply tripped while switching on the transformer.								
→ Abnormal high noise after several hours of service.								
	→ Overheating at no load							
		→ Overheating at normal load						
			→ Unequal or unstable voltages on phases at equal load on all phases.					
				→ Trip by internal transformer fault (Buchholz, Pressure relay, On Load tap changer,.)				
					→ Trip by external protection relays during normal service (Time current, ground fault, etc.)			
						→ Possible cause of malfunction	Rectification measures	
X							Supply voltage is too high, leading to excessive inrush current / core loss.	Do not exceed 105% of the ref. voltage; reset the tap changer in the right position.
X						X	Wrong protections relay setting. (Inrush current, etc.)	Check and reset protection relays
X						X	Circulation current between parallel transformers	Check all parallel operation conditions; set tap changers for the same voltage ratio.
	X						Loose parts on the core/windings; possibly caused by transport damage.	Switch off; consult the manufacturer
		X					Cooling system is insufficient.	Check that valves of all coolers are in the right working position. Check air, oil and water supply Check fan / oil pump operation. Note: At OFAF cooling, oil pumps always have to be in operation (even at no load)
			X			X	Overloading. Fault on the thermometer. Ambient temperature is too high	Reduce load. Check the thermometer. Check for faults in the secondary network
				X		X	Heavy peak loads, start currents etc. Bad contacts on internal or external connections. Internal transformer or tap changer fault.	Check for change of the load. Consult the manufacturer for further actions
					X		Malfunction of the measuring instrument. Internal transformer fault.	Check the measuring instrument. Switch off; consult the manufacturer
						X	Fault or short-circuit in the secondary network. Internal transformer fault.	Check the secondary network. Repeat all checks and tests as if it were the first energising. Consult the manufacturer.

B) Mechanical Malfunctioning

Mechanical malfunction, Observations made								
Oil level is not correct								
→ Alarm on Buchholz, gas relay								
	→ Alarm on temperature devices							
		→ Fans or oil pumps do not work						
			→ Insulation resistance is too low					
				→ Power factor is too low				
					→ Visual oil leaks			
						→ Possible cause of malfunction	Rectification measures	
X							Level indicator is defective Low oil level due to oil leak(s)	Repair or replace level indicator. Locate oil leak(s); repair leak(s). Replace leaking device or gasket(s)
	X						Insufficient air venting during erection. Fault gas production.	Gas analysis is recommended. Consult manufacturer for further actions
		X					The ambient temperature is too high. Overloading. Malfunction of the temperature devices. Malfunction of the cooling system	Reduce load. Check / replace temperature device
			X				Defect on temperature detecting system. Devices are defective.	Check detecting system. Replace defective devices
				X			Contamination on bushings, etc. Penetration of humidity in the insulation System	Clean-up external bushings, terminals,. Consult the manufacturer
					X		Degradation of the insulation system	Clean-up external bushings, terminals,. Consult the manufacturer
						X	Defective gaskets	Tighten bolts. Replace gaskets

Annexure List

Annexure	Description
I	Receiving inspection report
II	Energising report
III	Parts ordering form Cum Parts price request
IV	Site Installation Report
V	Site Commisioning Report

Receiving inspection report		**General Engineering Works** www.geworks.co.in services@geworks.co.in
Date of report:		
Transformer Serial No:		

1	**Customer and Equipment information**					
	A	**Customer information**				
	☐	Customer Name:				
	☐	Contractor Name:				
	☐	User name:				
	☐	Purchase Order No:				
	☐	Additional information:				
	B	**Equipment Information**				
	☐	Rating:		KVA	/	kV
	☐	Arrival location:				
	☐	Date of arrival:				
	☐	Transport by:	☐VESSEL ☐TRAIN ☐TRUCK ☐PLANE			
	☐	Additional Information:				
2	**Arrival conditions of the equipment**					
	☐	Equipment inspected by (name and function):				
	☐	Has the transformer been subjected to all recommended arrival inspections and tests?	☐YES ☐NO			
	☐	Visual external inspection of the transformer:	☐OK ☐NOT OK			
	☐	Inspection of all means for blocking and securing:	☐OK ☐NOT OK			
	☐	Oil leaks:	☐OK ☐NOT OK			
	☐	Inspection of the impact recorder (If provided):	☐OK ☐NOT OK			
	☐	Recorder type and serial number(If provided):				
	☐	Follow instruction for Shock Recorder:				
	☐	Inspection of the inert gas pressure system (If Provided)	☐OK ☐NOT OK			
	☐	Tank pressure, (If gas filled > 0.05 bar):	☐OK ☐NOT OK			
	☐	Pressure of gas bottle (if) in use (> 3 bar):	☐OK ☐NOT OK			
	☐	Is the equipment (transformer and parts) undamaged and complete? (if No, specify below)	☐YES ☐NO			
	☐	Remarks on arrival of the equipment:				
3	**Appendices**					
	☐					
	☐					
4	**Date, name(s), function and signature(s)**					

Remarks: Complete this report and send it to your GEW contact person. If there is any damage or missing material, follow the procedures mentioned in the OEM manual.

Energizing report		**General Engineering Works** www.geworks.co.in services@geworks.co.in
Date of report:		
Transformer Serial No:		

1	**Customer and Equipment information**					
	A	**Customer information**				
	☐	Customer Name:				
	☐	Contractor Name:				
	☐	User name:				
	☐	Purchase Order No:				
	☐	Additional information:				
	B	**Equipment Information**				
	☐	Rating:		KVA	/	kV
	☐	Site Location:				
	☐	Delivery date:				
	☐	Additional Information:				
2	**Energising Information**					
	☐	Energising Date				
	☐	Energising Time				
	☐	Atmospheric condition				
	☐	Ambient temperature (°C)				
	☐	Additional information concerning energising conditions:				
	☐	Have all the tests and inspections listed in the “Site commissioning report” been performed?	☐YES	☐NO		
	☐	Has a copy of the “Site commissioning report” been sent to GEW (in case erection and commissioning has not been done or supervised by GEW)?	☐YES	☐NO		
	☐	Has energising been successful and without any problems?	☐YES	☐NO		
	☐	Remarks on energising:				
3	**Appendices**					
	☐					
	☐					
	☐					
4	**Date, name(s), function and signature(s)**					

Remarks: Complete this report and send it to your GEW contact person. ***WARRANTY IS VOID*** *without this report being sent to GEW within 3 days of energizing*

Parts ordering form Cum Parts price request		**General Engineering Works** www.geworks.co.in services@geworks.co.in
Date of report:		
Transformer Serial No:		

1 Customer and Equipment information

	A	**Customer information**				
	☐	Customer Name:				
	☐	Customer P/O No [1]:				
	☐	Contact person:				
	☐	Tel:				
	☐	Fax:				
	☐	Additional information:				
	B	**Transformer information**				
	☐	Transformer serial no:				
	☐	Rating:		KVA	/	kV
	☐	Date of energising:				

2 Information on parts delivery

	☐	Type of parts:	☐Replacement of defective parts ☐Spare parts
	☐	Delivery terms:	
	☐	Delivery Address:	
	☐	Tel:	
	☐	Fax:	

3 Parts

	Part Name	Description	Qty

4 Date, name(s), function and signature(s)

(1) When ordering parts: an official Purchase Order with reference to our quotation is required.
(2) Item No's are provided on the General Arrangement Drawing and Materials List

Site Installation Report					
Customer:					
Date:		Order No:			
Transf. Sr. No.:		Rating (KVA):			
Voltage Ratio:		Taping Range:	+ %, - %		
Tap changer type	OCTC / OLTC	Vector Group			
Installed at:					
a) **OLTC Details:**					
Make:		Sr no.			
Type	In tank/ Out tank	Counter reading			
b) **RTCC Details:**					
	Make:		Type	Independent/Master/Follower	
c) **AVRR Details:**					
	Make		Sr No.		
a) Details of Bushings:					
H.V. Bushings	Make		kV		
	Sr Nos.	U – V – W –			
L.V. Bushings	Make		kV		
	Sr Nos.	U – V – W –			
b) Details of Magnetic Oil Level Gauge:					
Magnetic Oil level gauge on main conservator	Make:		Type:		
	Wired for	Alarm	Yes / No		
		Trip	Yes / No		
	Tested for	Alarm	Yes / No		
		Trip	Yes / No		
Magnetic Oil level gauge on OLTC conservator	Make:		Type:		
	Wired for	Alarm	Yes / No		
		Trip	Yes / No		
	Tested for	Alarm	Yes / No		
		Trip	Yes / No		

c) Details of Buchholz & Oil Surge Relays:				
Buchholz Relay	Make:		Type:	
	Wired for	Alarm		Yes / No
		Trip		Yes / No
	Tested for	Alarm		Yes / No
		Trip		Yes / No
Oil Surge Relay (on OLTC)	Make:		Type:	
	Wired for	Trip		Yes / No
	Tested for	Trip		Yes / No
Notes: 1) Both the relays connected in control circuitry Yes / No 2) Control Circuit Checked for operations through:				
(a) Buchholz Relay				Yes / No
(b) Oil Surge Relay				Yes / No
d) Details of Breathers:				
Main Tank Breather:	Make:		Type:	
	Colour of Silica Gel:			Blue / Pink
	Oil Level in Breather:			OK / Not OK
OLTC Breather:	Make:		Type:	
	Colour of Silica Gel:			Blue / Pink
	Oil Level in Breather:			OK / Not OK
e) Details of Radiators & Radiator Valves:				
Radiators:	Make:		Type:	
	Nos:			
Radiators Valves:	Make:		Type:	
	Nos:			
i) Details of O.T.I. & W.T.I.:				
Oil Temp. Indicator:	Make:		Type:	
	Tested for	Alarm		Yes / No
		Trip		Yes / No

	Set for	Alarm		°C
		Trip		°C
Winding Temp. Indicator:	Make:		Type:	
	Tested for	Alarm		Yes / No
		Trip		Yes / No
	Set for	Alarm		°C
		Trip		°C
h) Pressure Relief Device(PRD):				
Pressure relief Device	Make:		Type:	
	Tested for	Alarm		Yes / No

NOTE:

(1) O.T.I. & W.T.I. connected in control circuitry Yes / No

(2) Control Circuit checked for operations through.

OTI -	Yes / No
WTI -	Yes / No
PRD -	Yes / No

Date, name(s), function and signature(s)		

- *This report should be sent to GEW within 3 days of charging*
- *Warranty will be VOID if this report is not sent to GEW within stipulated time*

Note: For PRD / PRV, Please ensure to remove the full blank gasket (if provided) before oil Circulation / charging of transformer.

Site commissioning report

Cover sheet

Project	
Customer	
Customer reference	
Order number	
Site	
Country	
GEW Reference	

Serial number	
MVA	
HV	
MV	
LV	
Vector group	

Attached test result sheets

Date

GEW's Representative	Client's Representative
Name	**Name**
Signature	**Signature**

MECHANICAL INSPECTION

Before start of erection.

	Damage	No damage
Visual inspection of main tank for transport damages	☐	☐

	Damage	No Damage
Visual inspection of crates containing transformer parts. If there is a visible damage, write a report. If possible, take photographs of this damage and notify the client/insurance company.	☐	☐

Remarks :

Inspection of shock recorder.

Have electronic files been analyzed by GEW ? ☐ YES ☐ NO

AFTER ERECTION

General Checks	OK	Not OK	NA
ground connections of all accessories			
distance between lightning rods & ground (mm)			
check position of all valves			
Position of flap valves (radiators)			
oil level transformer			
oil level tap changer			
desperation of relevant parts			
absence of oil leaks			
absence of tools on transformer			
markings, terminal plate, rating plate			
air breather(s) : oil lock, silica gel condition			
painting			

GEW's Representative	Client's Representative
Name	**Name**
Signature	**Signature**

MECHANICAL & ELECTRICAL CHECKS

ON LOAD TAP CHANGER.	OK	Not OK	NA
Are all the necessary supply voltages available?			
Synchronization of motor drive / tap changer			
Manual test of end positions			
Electrical test of end positions			
Local electrical control of tap changer			
Remote electrical control of tap changer			
Heating : functioning and control			

OFF LOAD TAP CHANGER	OK	Not OK	NA
Synchronization of drive / tap changer			
Functional test			
Functioning of mechanical interlocks			

LINKS INSTALLED UNDER TX COVER	OK	Not OK	NA	Voltage
Check position of links --> operating voltage				

CONTROL CABINET	OK	Not OK	NA
External wiring completed			
Current transformers connected or short circuited			
All wiring insulation tested with 500V (except remote) position indicator			
Tightness of connections			
Phase rotation of incoming supply			
Rotation of each fan			
Rotation of each pump			

GEW's Representative	Client's Representative
Name	Name
Signature	Signature

OPERATIONAL TESTS & CHECKS OF MEASURING AND CONTROLLING DEVICES			
	OK	**Not OK**	**NA**
Manual control of fan operation			
Thermal device control of fan operation			
Manual control of pump operation			
Thermal device control of pump operation			
Breaker contact operation of pump control			
Oil flow indicator(s)			
Automatic changeover of supply voltage			
Heating: functioning and control			
Indication of “Fans working” and contact (if applicable)			
Indication of “Pumps working” + contact (if applicable)			
Indication of “Tap changer running” + contact (if applicable)			

ALARM CONTACTS			
	C.C.	**CLIENT**	**NA**
Buchholz transformer			
Buchholz cable boxes			
Oil level transformer minimum			
Oil level tap changer maximum			
Oil level tap changer minimum			
Oil temperature alarms			
Winding temperature alarms (primary)			
Winding temperature alarms (secondary)			
MCB cooling supply			
C.C. supply-control relay(s)			
MCB tap changer supply			
Tap changer supply-control relay			
Aux. contacts of fan MCBs			
Aux. contacts of pump MCBs			

TRIP CONTACTS			
	C.C.	**CLIENT**	**NA**
Buchholz relay on transformer			
Tap changer protective relay			
Pressure relief device 1			
Pressure relief device 2			
Pressure relief device on cable boxes			
Oil temperature trip			
Winding temperature trip (primary)			
Winding temperature trip (secondary)			
Non return flap valve			

TEMPERATURE SETTINGS

Thermostat	**°C**	**NA**
Start fans (pumps)		
Alarm		
Trip		

Oil thermometer	**°C**	**NA**
stop fans (pumps) or alarm 1st stage		
start fans (pumps) or alarm 2nd stage		
alarm		
trip		

WTI (primary)	**°C**	**NA**
stop fans / pumps (1)		
start fans / pumps (2)		
stop fans / pumps (2)		
start fans / pumps (2)		
alarm (1)		
alarm (2) or trip		

WTI (Secondary)	**°C**	**NA**
stop fans / pumps (1)		
start fans / pumps (2)		
stop fans / pumps (2)		
start fans / pumps (2)		
alarm (1)		
alarm (2) or trip		

INSULATION RESISTANCE MEASUREMENT		
Date :		
Atmospheric condition		
Ambient temperature		
Oil Temperature		
Tap changer position		
Megger		
Make		
Type :		

HV to (LV+Tank)		
Applied Voltage	.....	**kV**
	Measured Value	**Unit (MΩ / GΩ)**
1 min.		
2 min.		
3 min.		
4 min.		
5 min.		
6 min.		
7 min.		
8 min.		
9 min.		
10 min.		
PI Value*		

LV to (HV+Tank)		
Applied Voltage	.....	**kV**
	Measured Value	**Unit (MΩ / GΩ)**
1 min.		
2 min.		
3 min.		
4 min.		
5 min.		
6 min.		
7 min.		
8 min.		
9 min.		
10 min.		
PI Value*		

*PI (Polarisation Index) Value (IR value at 10 min / IR value at 1 min)

CORE - TANK INSULATION RESISTANCE MEASUREMENT

Applied voltage max. 2500 V.

Measured value [ ] MΩ

Make sure the link is re-established and tightened after measurement

OIL TEST RESULTS	
Sampling date	
Atmospheric condition	
Ambient temperature	
Oil temperature	
Testing date	
Ambient temperature	
Oil temperature	

DIELECTRIC STRENGTH	
Instrument used	
Make	
Type :	

BREAK DOWN VOLTAGE (BDV) OF OIL			
	Sample 1	**Sample 2**	**Sample 3**
Sampling Location			
Gap of electrodes	2.5mm	2.5mm	2.5mm
Reading 1	**kV**	**kV**	**kV**
Reading 2	**kV**	**kV**	**kV**
Reading 3	**kV**	**kV**	**kV**
Reading 4	**kV**	**kV**	**kV**
Reading 5	**kV**	**kV**	**kV**
Average Value(*)	**kV**	**kV**	**kV**

(*) For Ester Oil transformer 10 readings required to take for the average value of Oil BDV.

PPM (Water Content of Oil)

Sample 1 ppm **Sample 2** ppm **Sample 3** ppm

GEW's Representative	Client's Representative
Name	**Name**
Signature	**Signature**

VOLTAGE RATIO TEST

Test performed by bridge	
Test performed by voltmeter	
Instrument make:	
Instrument type:	

If by V-meter, note measured phases and volts

If by bridge, note injected phases, measured phases and values

	U Phase	V Phase	W Phase
Input Supply			

Tap No	U Phase	V Phase	W Phase
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

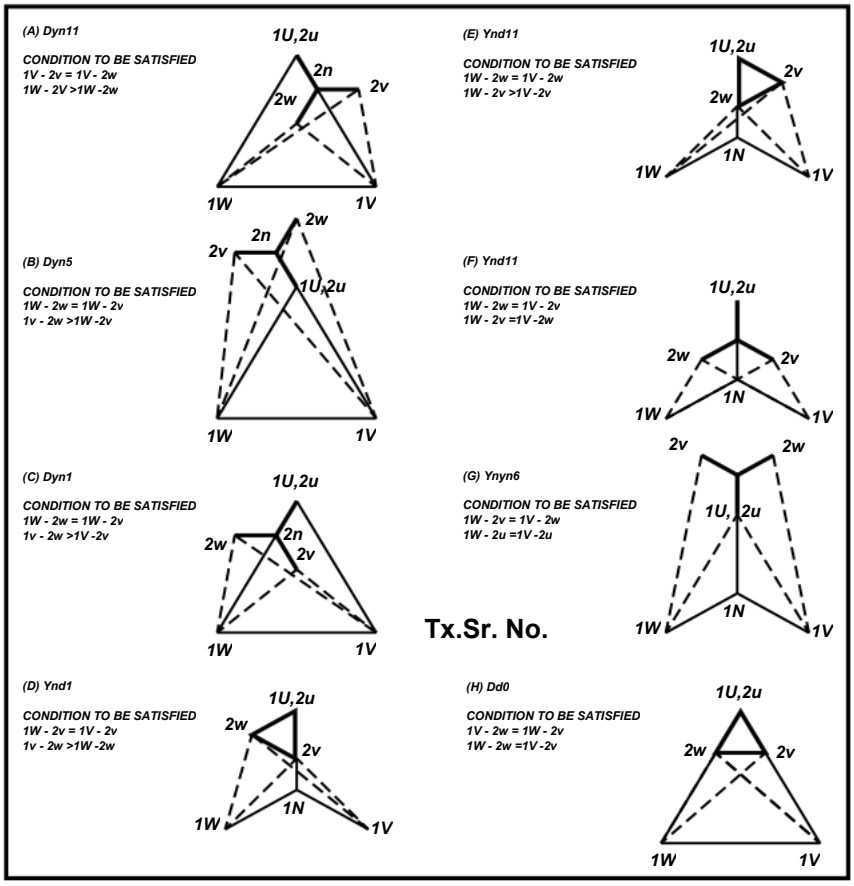
VECTOR GROUP TEST

Applied Voltage		Volts
1U-1V		Volts
1V-1W		Volts
1W-1U		Volts

Measured Voltage Across		
		Volts
		Volts
		Volts
		Volts
		Volts
		Volts

Equation		

Vector Group	



Winding Resistance Measurement

Oil Temp.: **Winding Temperature:**

Primary Winding:

Tap No			
	Ω / mΩ	Ω / mΩ	Ω / mΩ
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

Secondary Winding:

Ω / mΩ	Ω / mΩ	Ω / mΩ

Tan delta measurement **Tx.Sr. No.**

Date	
Atmospheric condition	
Ambient temperature	
Oil temperature	
Tap changer position	
Test device	
Make	
Type	

HV - LV + Tank		% L- GND
HV - Tank		% L- Guard
HV - LV		%
LV - Tank		% H-Guard
LV - HV + Tank		% H-GND

GEW's Representative	Client's Representative
Name	**Name**
Signature	**Signature**

CURRENT TRANSFORMER CHECKS

Tx.Sr. No.

Location:		Name	
Specs.		Ratio	

Insulation resistance with 2500V					P1=
Voltage					P2=
Current					S1=
Connections tightened or shorted					S2=

Location:		Name			
Specs.		Ratio			
Insulation resistance with 2500V					P1=
Voltage					P2=
Current					S1=
Connections tightened or shorted					S2=

Location:		Name			
Specs.		Ratio			
Insulation resistance with 2500V					P1=
Voltage					P2=
Current					S1=
Connections tightened or shorted					S2=

Location:		Name			
Specs.		Ratio			
Insulation resistance with 2500V					P1=
Voltage					P2=
Current					S1=
Connections tightened or shorted					S2=

Location:		Name			
Specs.		Ratio			
Insulation resistance with 2500V					P1=
Voltage					P2=
Current					S1=
Connections tightened or shorted					S2=

GEW's Representative	Client's Representative
Name	**Name**
Signature	**Signature**

ZERO PHASE SEQUENCE IMPEDANCE DETERMINATION

1) Short circuit on HV winding

2) LV winding open, no load

3) Apply single phase voltage between Hv winding and HV neutral (220 . 240 V)

4) Measure currents going to each phase

tap pos	applied V	measured line current A B C			average current (A+B+C)/3	ZPS Impedance applied V / av.Curr.
lowest						
nominal						
highest						

GEW's Representative	**Client's Representative**
Name	**Name**
Signature	**Signature**

AUTOMATIC VOLTAGE REGULATION CHECK

Device(Type)	
Make	
Serial Number	

Simulate the P.T. voltage and balance the relay on this voltage (no pre-signal). While the bandwidth is set at 1%, increase the voltage by approximately 1.2 %. After the set time delay the tap should move to a lower position (more winding turns in primary).
Lower the simulated P.T. voltage to approximately 1.2 % below the desired P.T. voltage.
The tap should move to a higher position (less winding turns in primary).

	Y	N
Did the relay pass this function test ?		

	OK	NOT OK	NA
Check under voltage blocking			
Check overvoltage rapid return			
Check various time delays features			

GEW's Representative	**Client's Representative**
Name	**Name**
Signature	**Signature**

CONCLUSION **Tx.Sr. No.** |

Corrections to be made.

Other remarks.

The transformer ready to be energized	**Yes**	**No**

***Remark regarding minimum rest period before energizing*.**

Transformer equipped with oil pumps:
Let the pumps operate for 2 hours
Minimum rest period of 8 hours
Transformer without oil pumps:
Minimum rest period of 16 hours after filling

GEW's Representative	**Client's Representative**
Name	**Name**
Signature	**Signature**

Customer Service

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