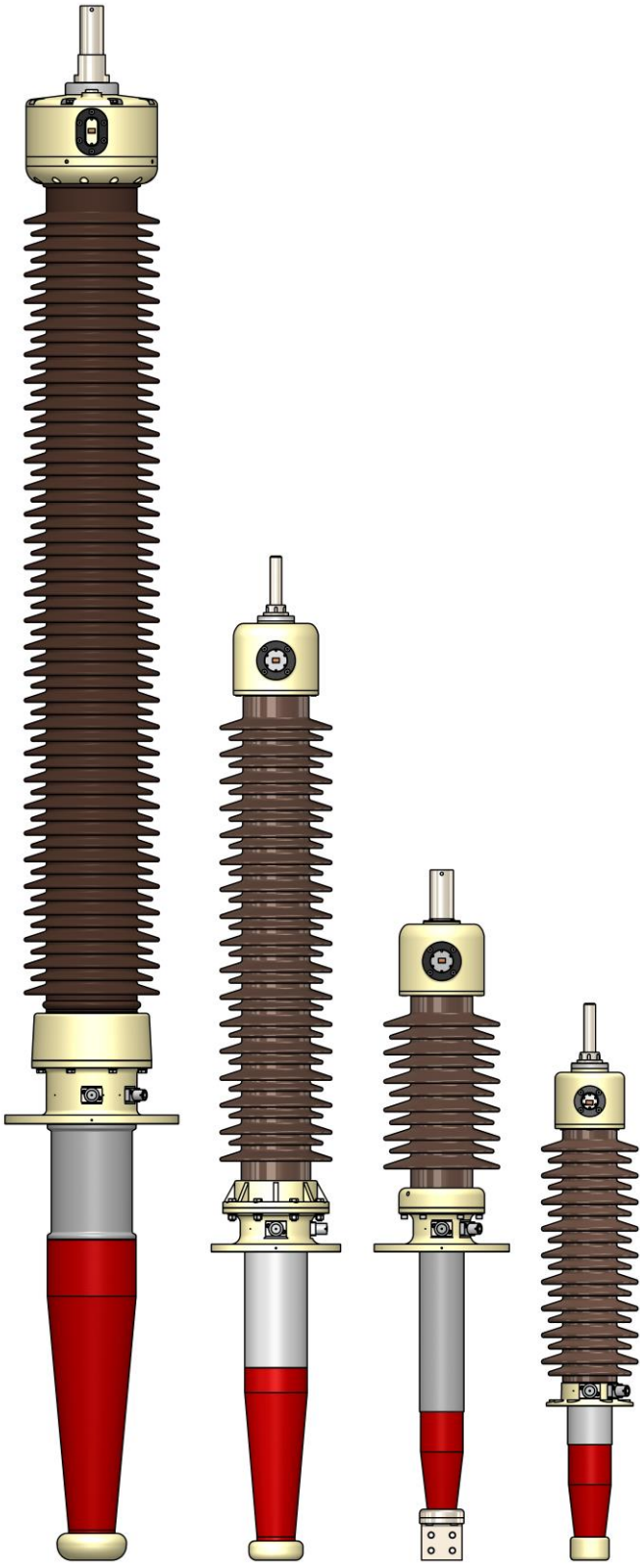


# INSTALLATION, OPERATION, MAINTENANCE INSTRUCTIONS

# OIP BUSHINGS UPTO 245 kV

## CONTENT

# 1. INTRODUCTION

## 1.1. GENERAL

Read this manual carefully and follow all safety regulations. Work on bushings must be performed only by qualified personnel. For personnel safety, before any action in the field, inform the responsible site in-charge.

All the pictures and description in this manual are representative and actual bushing may differ in size, shape, orientation, material of construction and concept of design without affecting intended performance of the Bushing or need of significant change in instructions to install, operate and maintain the bushing.

## 1.2. SAFETY

| | |
|---|---|
|  | Safety instructions of the operating and principal company supersedes and must be followed. |
|  | Only materials supplied by YASH shall be used (example: Air end HV terminal, Oil end HV terminal, O-rings, Oil end electrode, arcing horns, test tap cap etc.) |
|  | **Caution** FAILURE TO COMPLY WITH SAFETY RULES CAN BE FATAL AND CAN CAUSE DEATH!<br>Work on system must be performed after disconnecting system from the mains, securing against reconnection, and discharging the system to earth potential by connecting the earthing rod between Air end HV terminal and Earth |
|  | **Caution** Strong electromagnetic fields can be present nearer to the bushings. People with pacemakers may not go near!<br>Sensitive technical devices must be protected by appropriate measures. |

## 1.3. STORAGE AND TRANSPORTATION

| | |
|---|---|
|  | **Attention** Bushings must be always protected from Direct exposure to rains / atmospheric moisture and humidity. |
|  | **Attention** Oil end Epoxy Insulator is meant for duty inside Oil and must not be exposed to direct sunlight in outdoor environment to avoid deterioration of its properties. |
|  | **Hint** Bushing should be stored and transported in its original Packing box and should be stored indoor. |

The bushings are packed and supplied in a fully covered wooden box. Each bushing is sealed individually in a polythene bag. A Silica granule (desiccant material) bag is placed on Oil-side of OIP Bushing to absorb moisture during the storage period.

Figure 1.1: Wooden Packing box

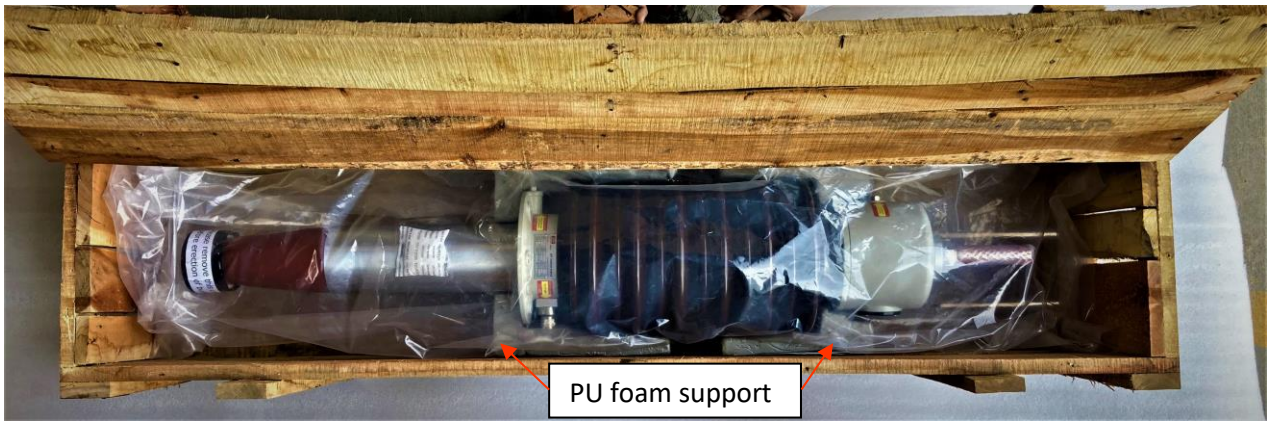



Figure 1.2: Bushing packed with polythene bag cover and Bottom PU foam support

Obvious damage to packing box and any oil leak from packing box must be informed to YASH immediately.

As Porcelain Insulator is fragile, Shock-watch labels are placed on both ends of the OIP Bushing packing box to monitor if the Bushing encountered shocks beyond its acceptable limit. The sensitivity of the ShockWatch label indicator is decided based on gross weight and volume of the bushing packing box.


Not Activated = Shocks within acceptable limit  Activated = Shocks beyond acceptable limit

Figure 2: Comparision of Activiated and Not-activated ShockWatch label

In case the ShockWatch label is observed to have turned red then verify the bushing packing box and whole bushing closely for any oil leakage, visual damage and Oil level in vertical position. Immediately Inform findings to YASH for next course of action.

## 2. PRODUCT DESCRIPTION

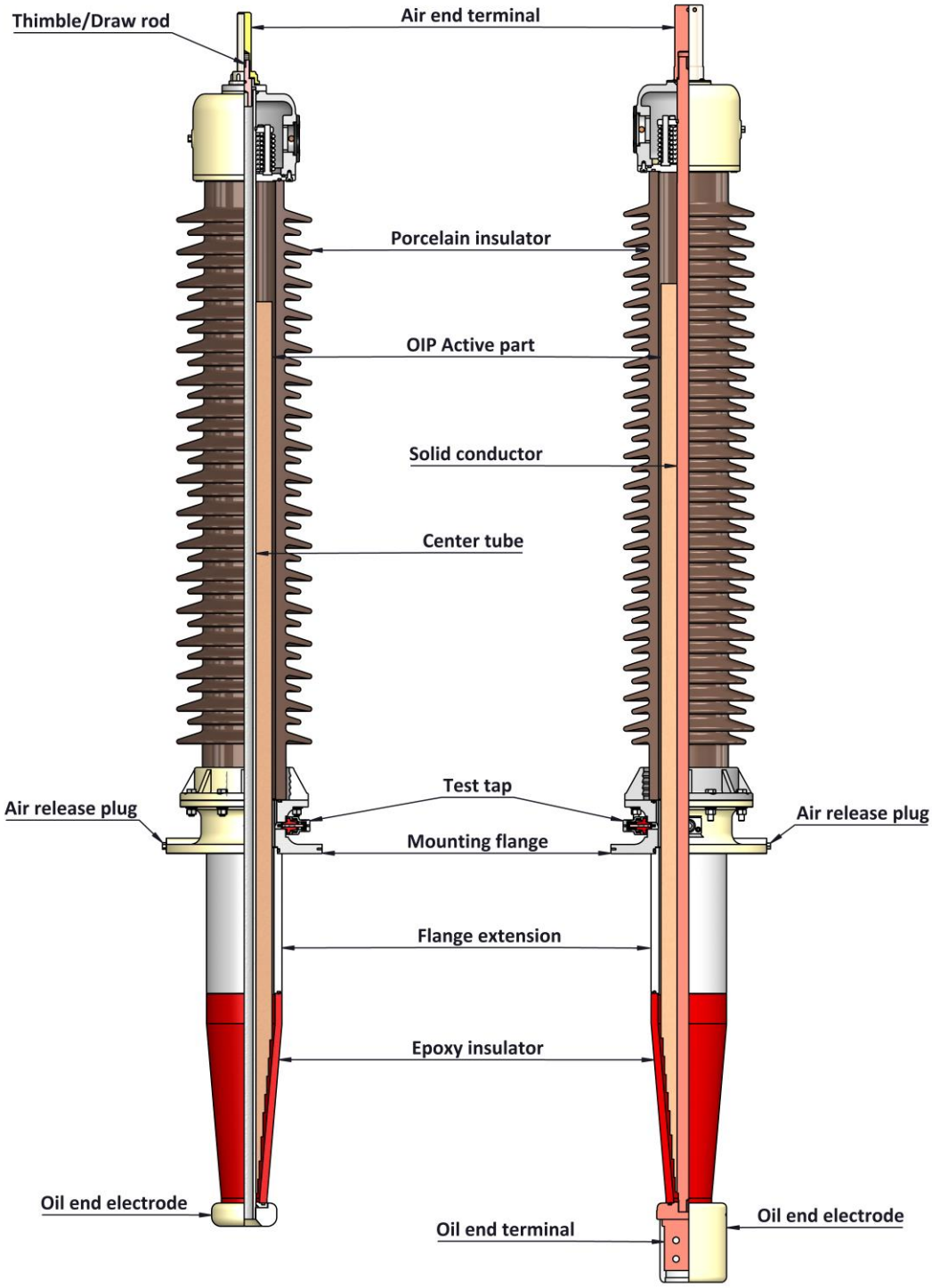



Figure 3: Bushing construction

Transformer Bushings for Oil to Air application with OIP Insulation and Porcelain Insulator are designed to meet the requirements of IEC-60137:2017 and operating conditions thereof. The bushing is designed to operate with parts above mounting flange in air and parts below immersed in Mineral transformer oil.

| | |
|---|---|
| | **Hint** In case if the bushing is to be used in Transformer filled with Ester Oil, prior consent from YASH must be taken. |

YASH make bushings are designated as below.

| | | | |
|---|---|---|---|
| 1 | Voltage class: | V | High Voltage class Bushings upto 245 kV and 3150 Amp |
| 2 | Insulation type: | C | Oil Impregnated paper |
| 3 | Connection to transformer winding: | L | Draw-lead |
| | | D | Draw-rod type (Split or bottom connected) |
| | | S | Solid stem |

**Hint** Example: A 145 kV Bushing with OIP active part and having draw-lead connection arrangement is designated as VCL model.

Based on Current rating and Connection type to the transformer winding, different available models are designated as VCL, VCD, VCS.

**Description:**

The bushing is self-contained with OIP Condenser core. The OIP Insulation is formed by winding High Purity Insulating kraft paper on the centre pipe or conductor. Aluminium foils are inserted at specific locations during the winding of the paper to form capacitive grading for an Optimal axial and radial distribution of electrical field. The wound Condenser core is then dried under vacuum and subsequently impregnated with special insulating Oil to form the Active part.

The OIP Condenser core is assembled with Oil end Insulator, Flange extension, Mounting flange and Air end Insulator and is hermetically sealed. The entire bushing assembly is held together by pre-stressed spring assembly in the conservator of the bushing. Spring assembly compensates the effect of change in length of central tube/stem due to temperature variation and maintains required sealing pressure on entire housing assembly.

The annular space inside the bushing housing is filled with transformer oil up to half level in Oil level indicator and space above oil level is evacuated and flushed with Nitrogen (N2) gas, which works as cushion to compensate volumetric changes in oil due to temperature variation on account of site ambient and on account of temperature rise due to current flow during service.

During assembly a cable is soldered on to the last layer of conducting foil of condenser & is crimped to the test tap stem to form Test tap and enable measurement of Capacitance, Dielectric Dissipation Factor - Tan Delta / Power Factor, to assess dielectric properties of Insulating Condenser core and monitor health of bushing.

Test tap stem is moulded in epoxy resin to insulate it from mounting flange. The test tap stem/stud is connected to mounting flange by means of a spring-loaded test tap cover. The mounting flange in turn gets connected to Transformer Tank which is always earthed. Thus, Test tap is also, ensured as earthed.

The Bushing carries current through solid conductor or draw-rod/lead.

All metal parts are made of corrosion-resistant Aluminium or Copper or Brass material. Fasteners are of stainless steel.

## 3. GENERAL OPERATING CONDITIONS

| | | |
|---|---|---|
| Application | : | Transformer (Oil) - Outdoor (Air) |
| Ambient temperature | : | -20 to + 50 °C |
| Oil Temperature | : | ≤ 55 °C above ambient of 50 °C |
| Altitude of operation | : | ≤ 1000mt |
| Mounting angle | : | 0° to 30° from Vertical. |
| Creepage distance | : | ≥ 25 mm/kV |
| Oil level on bushing oil end | : | Up to Mounting Flange of the Bushing |
| Compliance standard | : | IEC 60137 |

*Special requirements are guaranteed in GA drawing and supersedes above data. Bushings with Special requirements are supplied against specific customer requirements.*

# 4. INSTALLATION

| | |
|---|---|
|  | **Caution** Do not work on systems that might be under High voltage! |

## 4.1 SUPPLY CONDITIONS

Accessories like Thimble/Draw-rod, Arcing horns (as per Order confirmation) etc. are supplied with appropriate packing and kept inside packing box. Check supply of all accessories as per Order confirmation and inform YASH HIGHVOLTAGE about short supplies if any.


Figure 4 : Electrode With PVC cap protection

Electrodes which are supplied as mounted on Bushing are protected by Protection cap.

| | |
|---|---|
|  | **Attention** Ensure no damage occurs to coating on Electrode while removing Protection cap. |

Figure 5 : Bayonet type electrode packing

Bayonet type electrode is protected by foam sheet and PVC mesh, packed inside Corrugated box. The box is held inside bushing packing box.

Figure 6 : Terminal Protection with PVC mesh

All terminals of Bushings are provided with PVC mesh to protect from transport & handling damage.

## 4.2 UNPACKING AND REMOVING BUSHING FROM PACKING BOX

**Attention** Use of hammer or other tools to open the packing box cover must be done carefully as they might damage the Porcelain insulator or insulating coating or electro-plated surfaces.

**Hint** Light weight bushing can be taken out of the wooden box by hand.
Heavier bushing should be lifted from the Wooden packing Box using lifting belts / ropes.

**Attention** Use of metal slings is not permitted.

**Hint** Remove Polythene cover and PU foam support from bushing and preserve them, so that it can be used for repacking of Bushing.

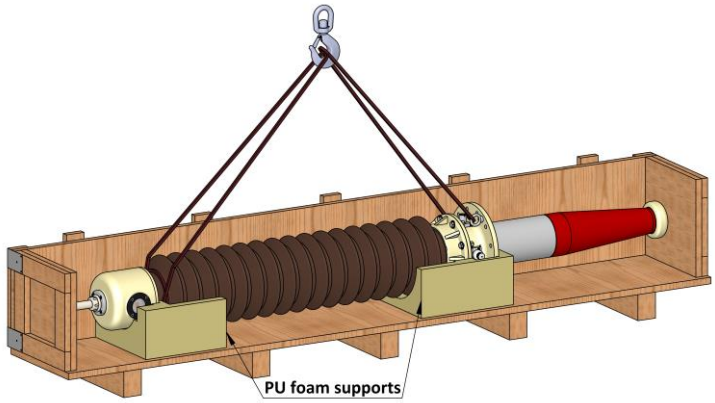



Figure 7: Lifting of bushing from box

**Attention** Bushings must be handled with care. Bumps, Impacts, and shocks must be avoided during transport and handling. Damage to the bushings must be reported immediately to YASH.

Bushings should be lifted by nylon belt/rope and appropriate lifting equipment. Place the bushing outside of wooden packing box on PU foam supports.

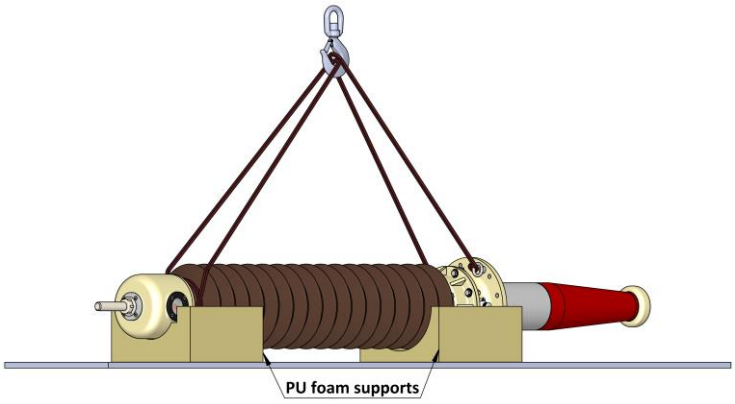



Figure 8: Bushing on protection pad and PU foam supports

**Attention** Bushing terminal holes should not be used for lifting the bushing. Terminals' surface must be protected from damage.

## 4.3 HANDLING THE BUSHING

The bushing can be handled and installed on the transformer at the correct mounting angle by using two cranes, or one crane with a hand winch to give the correct mounting angle.

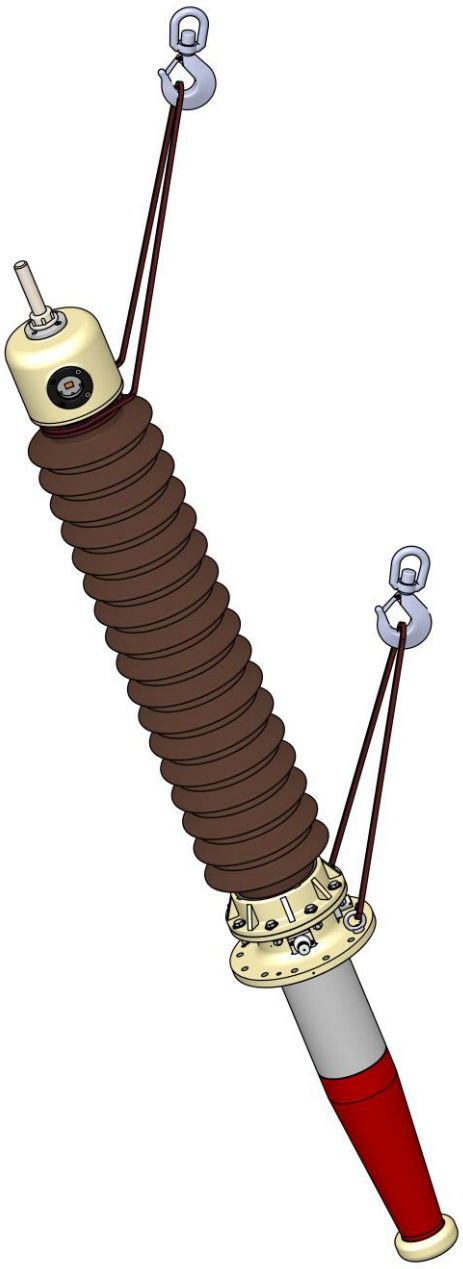


Figure 9: Bushing lifting with two cranes

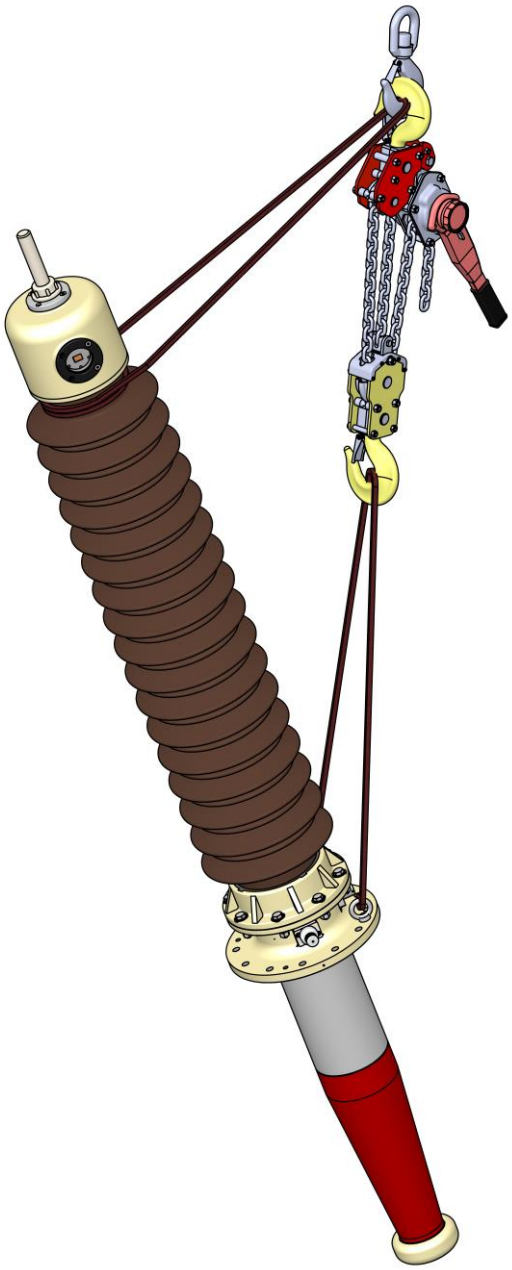


Figure 10: Bushing lifting with one crane & hand winch

| | |
|---|---|
| | **Hint** The M12 size lifting eye bolts fixed on flange are not part of supply. |

## CONNECTION OF DRAW-LEAD / SPLIT DRAW-ROD TYPE BUSHINGS

**Attention** Terminal connection to the thimble should be done carefully so that the threads are not damaged.

**Oil End clearances**

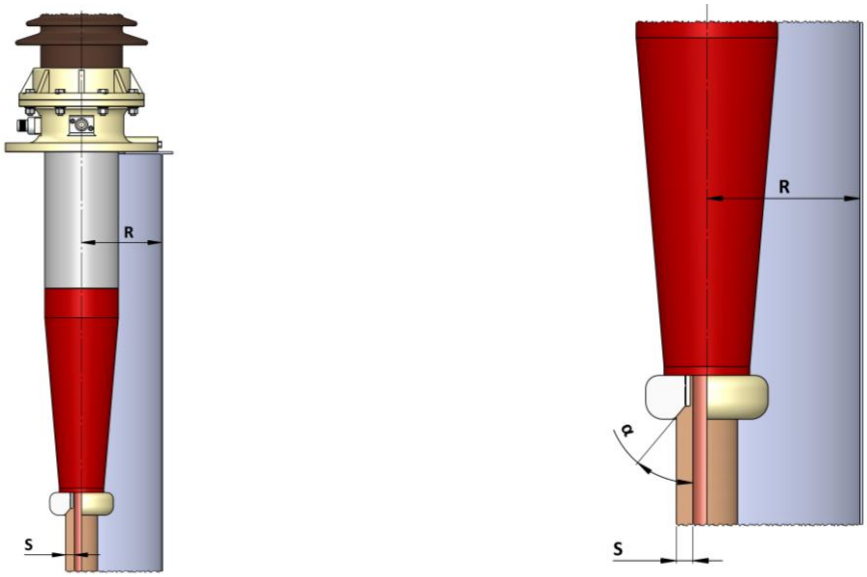



Figure 11: Insulating the transformer lead and turret clearances

YASH recommends to insulate the draw-lead from transformer winding to the bushing.
The minimum distance of earth part from bushing shall be 'R'. Value of R to be maintained as mentioned in General arrangement drawing (GAD). Value of 'Insulation thickness S' and 'Angle α' shall be chosen as per transformer manufacturer standard.

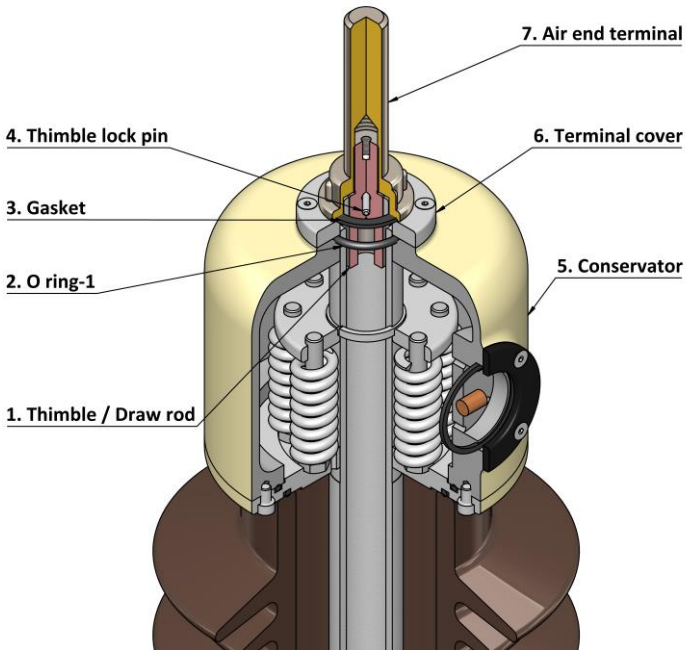



Figure 12: Bushing head detail

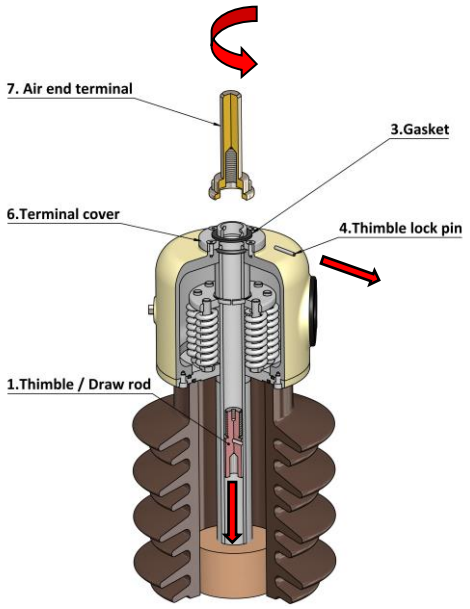



Figure 13: Remove thimble

1) Unscrew the 'Air end terminal' from 'Thimble'.
2) Remove cylindrical 'thimble lock-pin' from 'Terminal cover'.
3) Take out the 'Thimble' from bushing.

| | |
|---|---|
| | Retain the 'gasket' for later use. |

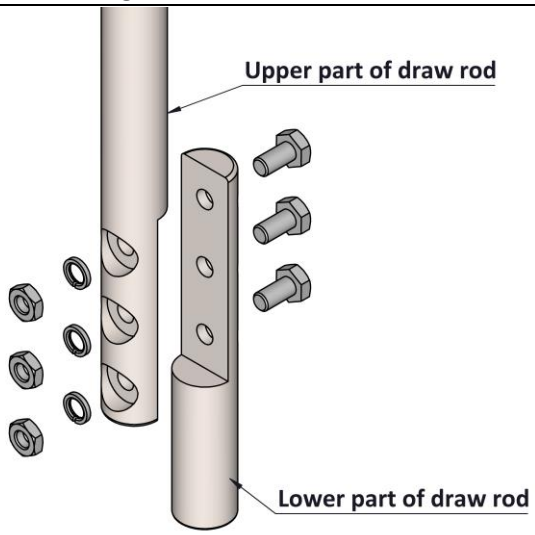



Figure 14: Split type draw-rod connection

4) Joint of Split type draw-rod is usually upto flange level and is supplied in two parts. Both Upper and lower part of Draw-rod are fixed by fasteners and supplied with bushing.
5) Lower part of Draw-rod is to be detached from upper part and to be connected to Transformer winding lead.
6) Lap joint of upper part of draw-rod and lower part of draw-rod to be done by hanging bushing above the transformer turret/tank and lowering the upper part of Draw-rod below bushing and connecting the lower part of draw-rod to it by using fasteners as shown in GAD. Generally, M10 size SS fasteners are used. Recommended tightening torque for M10 (SS fasteners) is 19 N.m.

| | |
|---|---|
| | Bushing can be dispatched to site with lower part of draw-rod connected to transformer lead and upper part of draw-rod inside Packing box. |

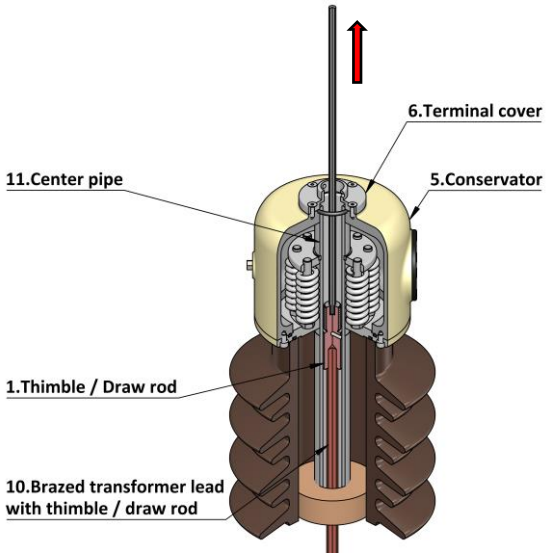



Figure 15: Pull the thimble / draw-rod

7) Pull the brazed/crimped-thimble/draw-rod, with 'transformer lead, using a pull through cord of suitable size, through bushing's centre pipe up to 'Terminal cover' using M10 bolt/rod and fixed on hole provided on top of thimble/draw-rod, while slowly lowering the bushing onto transformer.

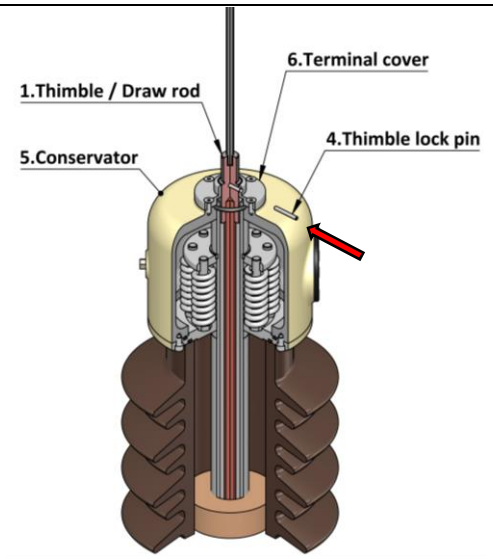



Figure 16: draw-lead with Transformer lead

8) Engage the thimble/draw-rod with Terminal cover by passing lock-pin through hole provided on them.
9) Remove the M10 pull through cord from thimble/draw-rod top side.

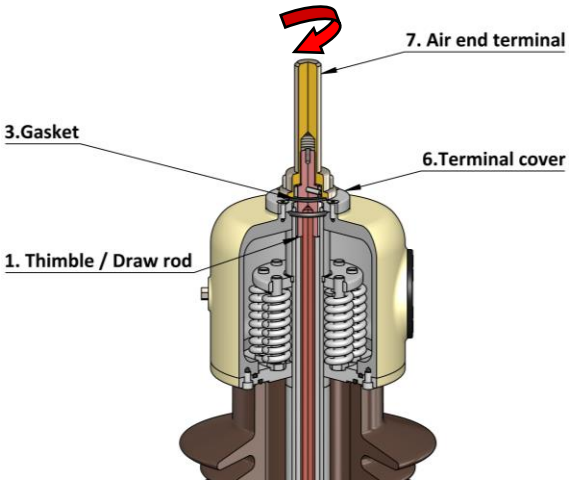



Figure 17: Terminal Tightening

10) Ensure proper placement of 'Gasket' on top of 'terminal cover'. Screw on 'Air end terminal' with 'thimble/draw-rod' and fully tighten by hand and then after, tighten it further about ½ to ¾ turn using adjustable spanner.

| | |
|---|---|
|  | **Caution** Any over tightening can cause thread damage/thread locking. |

## 4.5 PROCEDURE OF CONNECTING TRANSFORMER WINDING LEAD IN BOTTOM CONNECTED (SOLID STEM/FIXED DRAW-ROD TYPE) BUSHINGS

- Bushings with Bottom connected Draw-rod and Solid stem conductor are suitable for direct connection on both Air end and Oil end.
- Oil end side terminal can be directly connected to transformer lead by flat palm/lug connection from transformer winding.

| | |
|---|---|
|  | **Attention** Electrode-support and its fixing parts like helical springs, bolts, screws etc. should not be removed while electrode removal or refixing or during fixing of the transformer lead. (All parts are identified in Figure 19 and Figure 22.) |

| | |
|---|---|
|  | **Attention** Connection shall be done carefully so that the electrical contact surfaces are properly seated. Wipe clean all contact surfaces with a lint free cloth using suitable cleaning agent. |

| | |
|---|---|
|  | **Caution** Extensive care should be taken to avoid damage to the electrode or its coating while handling as it might lead to flashover/failure during service or testing of the bushing. |

| | |
|---|---|
|  | **Hint** Air end terminal for both bottom connected draw-rod and Solid stem Bushing is fixed before dispatch and are not required to be opened for connection of Bushing. |

Different type of Electrodes for Bottom connected Bushings.

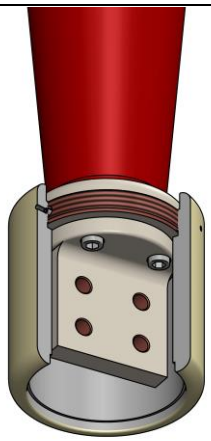


Figure 18.1: Removable Screwed type electrode fixed with grub screw

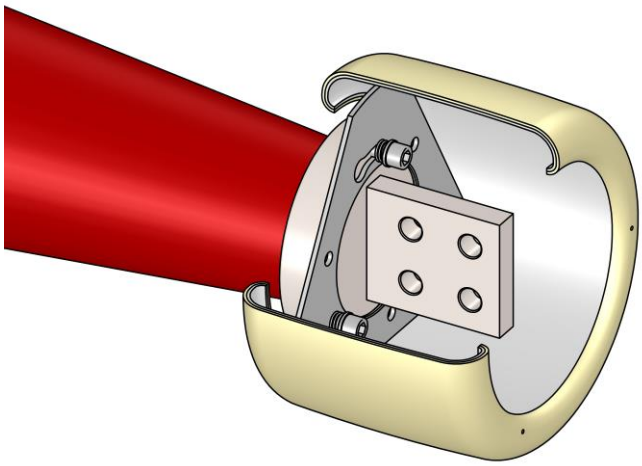


Figure 18.2: Removable Bayonet type electrode

### 4.5.1 BUSHINGS WITH SCREWED ELECTRODE

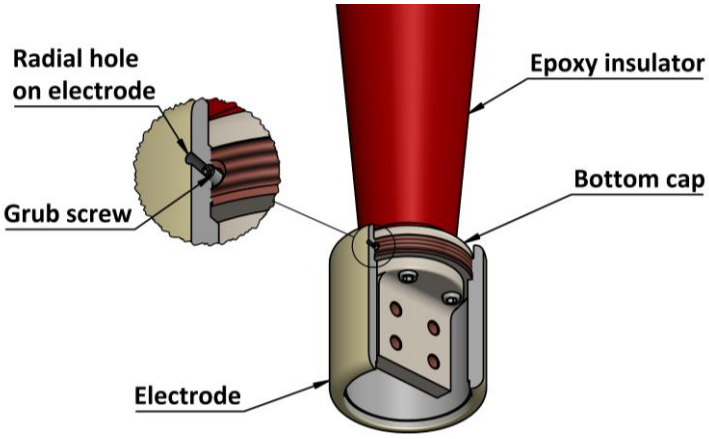



Figure 19: Removable Screwed type electrode

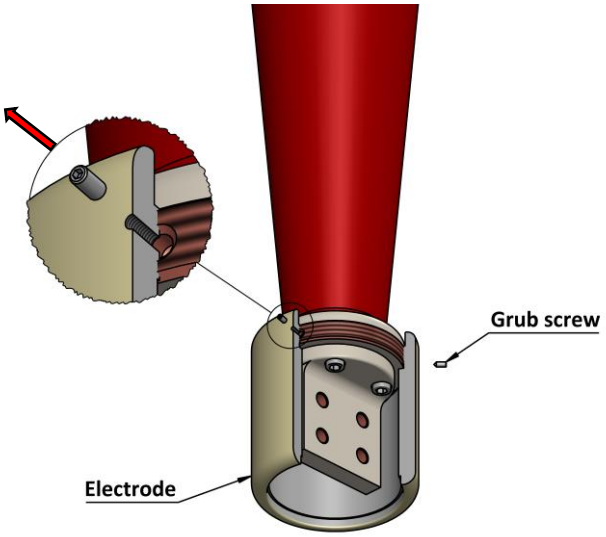



Figure 20.1: Remove screwed electrode

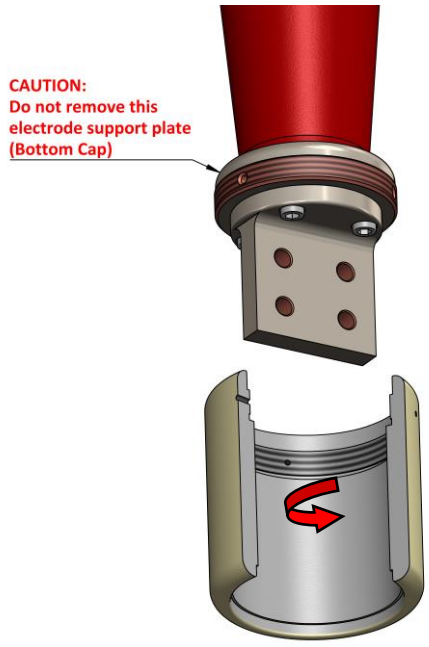



Figure 20.2: Unscrew and slide down screwed electrode

STEP-1 REMOVE THE ELECTRODE AND CONNECT TRANSFORMER LEAD TO BUSHING

| | |
|---|---|
|  | **Caution** Extensive care should be taken to avoid damage to the electrode or its coating while handling as it might lead to flashover during service or testing of the bushing. |

1) Mark the orientation of Electrode with respect to Oil end Insulator using Wax based pencil, this reference can be used to align the electrode while refixing the Electrode.

| | |
|---|---|
|  | **Attention** Remove wax pencil marking before closing manhole cover on transformer |

2) Unscrew all Grub screws inserted in radial holes on 'Electrode' by around 4 to 5 turns, so its thread engagement from Bottom cap is removed. Entire screw need not be removed from Electrode.
3) Unscrew the 'Electrode' from 'Bottom cap' and slide down over transformer winding lead.

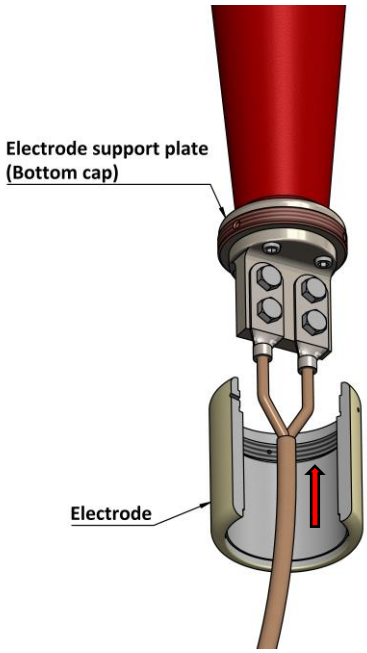



Figure 21.1: Fixing of transformer lead and Screwed electrode

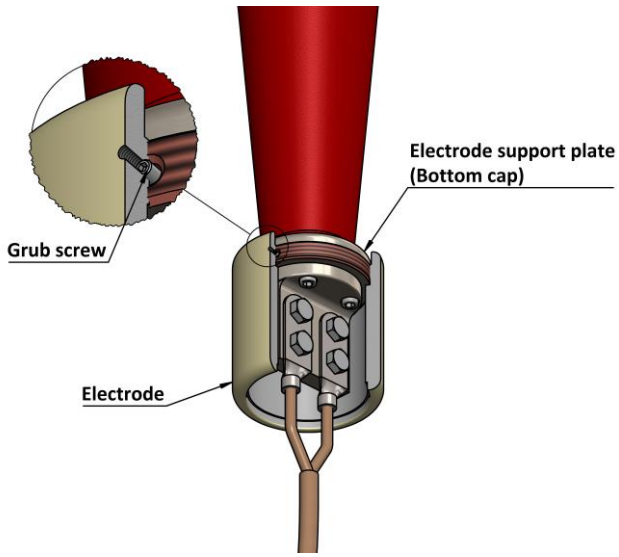



Figure 21.2: Fixing of transformer lead and Screwed electrode

**STEP-2 FIX THE ELECTRODE**

4) Connect transformer winding lead to the bushing's oil end terminal.
*5)* Slide up the 'Electrode' on transformer winding lead and screw it on 'Bottom cap'.
*6)* After screwing the electrode as per the original position, align the Electrode w.r.t. Oil end Insulator as marked in Step-1
7) Fix back all three grub-screw in radial holes of 'Bottom cap' and tighten fully.

### 4.5.2 BUSHINGS WITH BAYONET ELECTRODE

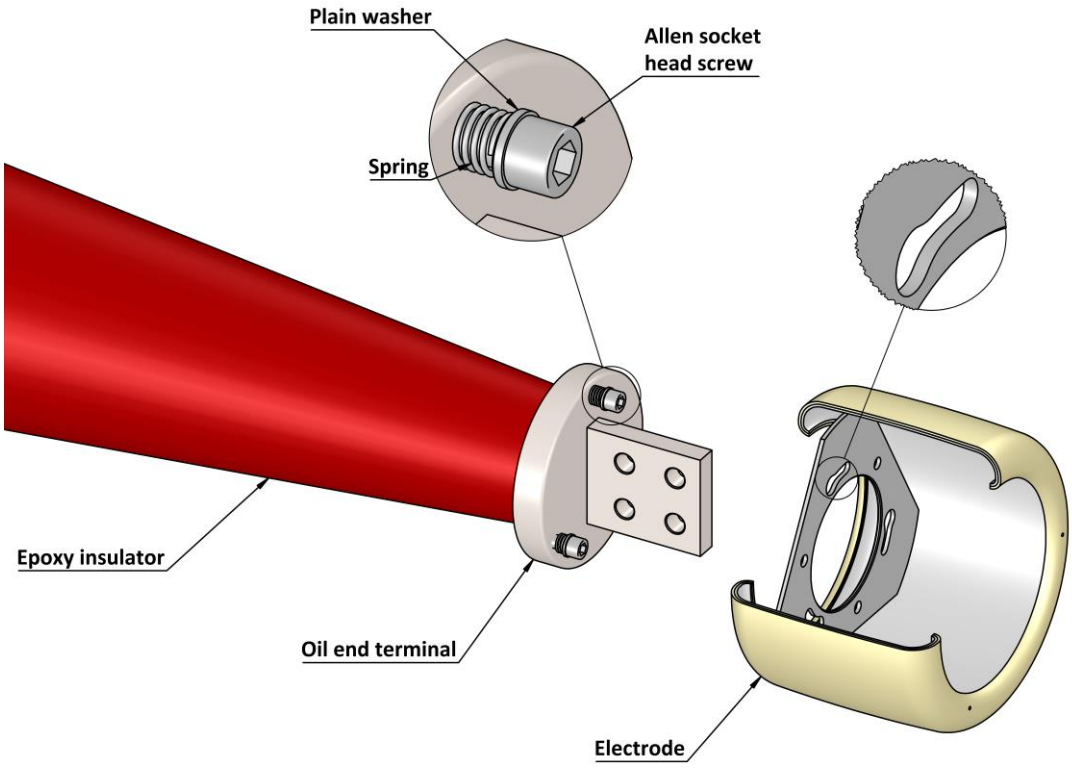



Figure 22: Bayonet electrode detail

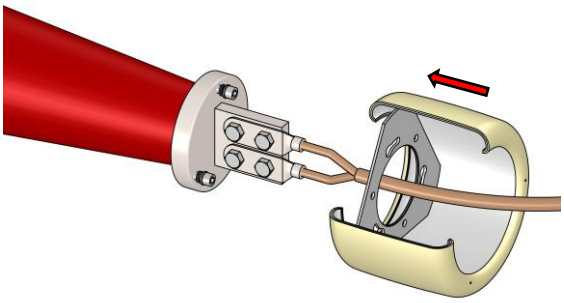


Figure 23: Fixing of transformer lead and bayonet electrode

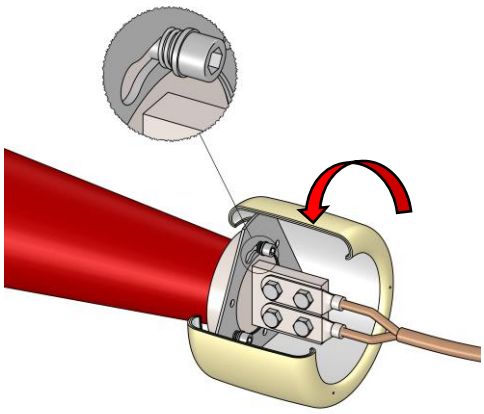


Figure 24: Fixing of transformer lead and bayonet electrode

**Step-1 REMOVE THE ELECTRODE TO CONNECT TRANSFORMER LEAD TO BUSHING**

1) Remove the Electrode (if present) by unlocking the bayonet lock.

| | |
|---|---|
| | Generally, the electrodes are supplied separately in the bushing packing box. |

2) Slide down the electrode over transformer winding lead. Connect transformer winding lead to the bushing's oil end terminal

**Step-2 CONNECT LEAD AND REFIX THE ELECTRODE**

3) Connect transformer cable / lead connection to the bushing's oil end terminal. Refix the electrode by rotating the electrode anticlockwise.

## 4.6 MOUNTING OF BUSHING

| | |
|---|---|
| | **Caution** The Current carrying contact surfaces of the bushing are electroplated; hence do not use emery or any abrasive material to clean them. |

| | |
|---|---|
| | **Attention** In order to maintain adequate electrical contact pressure, the terminal fasteners should be properly aligned and tightened. Failure to perform a proper connection may result in overheating of the bushing. |

| | |
|---|---|
| | **Attention** If an online monitoring system is to be installed on Bushing, YASH must be informed to verify suitability of the adapter to ensure proper electric contact and hermetic seal of test tap. |

| | |
|---|---|
| | **Hint** Refer GAD for Mounting instructions of Bushing which are designed for operation at mounting-angle greater than 30° from Vertical. |

- Clean the sealing surfaces of the bushing and transformer, oil-side and air-side, and make sure that everything is completely dry.
- Lift the bushing using lifting belt and place above the transformer at the designated place. Lower and mount the Bushing on the Transformer turret/tank after connecting the Draw-lead/Draw-rod of the Bushing as per section 4.4 of this manual.

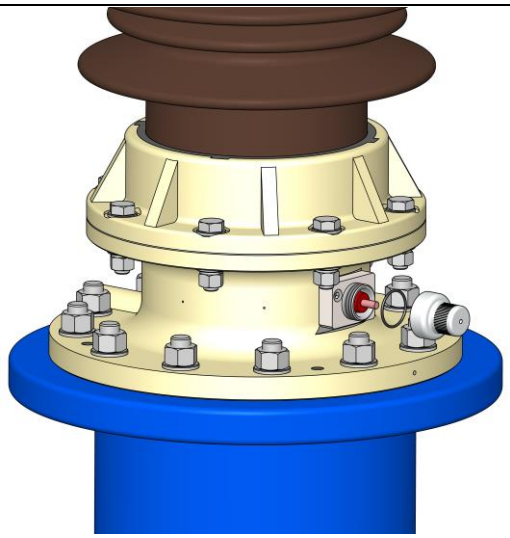


Figure 25.1: Fix test tap cap with o ring

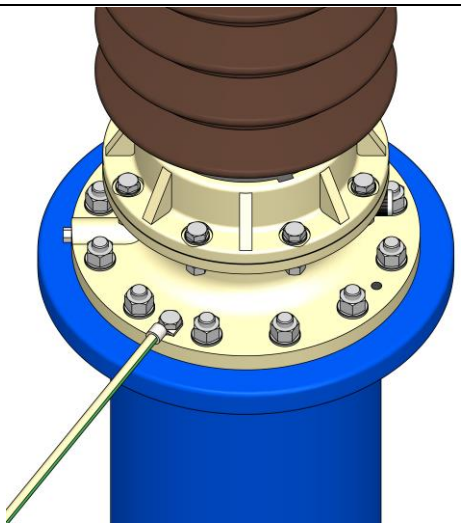
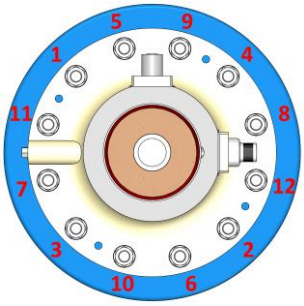


Figure 25.2: Connect earthing cable

Tighten the nut on the stud, welded on the turret/transformer body cover, to fasten the bushing flange with the transformer. Make the earthing between the flange and the transformer, using the M12 threads. Recommended size of earthing cable is braided copper with cross sectional area of atleast 50 sq.mm.

| | | |
|---|---|---|
|  | **Attention** Sequence of tightening the nut must be opposite i.e. criss-cross and not adjacent to each other.<br><br>Recommended tightening torque of mounting bolt for fastener shall be followed as per OEM guidelines. |  <br><br>Figure 26: Tightening sequence (Example – 145 kV Bushing) |

| | |
|---|---|
|  | **Caution** The test tap cap shall only be removed from Bushing if the power supply is disconnected. After the measurements, the cap must be closed tightly with O-ring.<br><br>If test tap cap is not closed effectively, this will result in the test tap stem not connected to earth or will be floating and dangerous voltages will be generated and will cause flashover between test tap stem and mounting flange & can lead to bushing failure and fire. |

| | |
|---|---|
|  | **Attention** Ensure proper alignment of threads on Test Tap Cap and the Mounting Flange, this is to prevent thread lock and permanent damage. |

| | |
|---|---|
|  | **Caution** Inadequate earthing of flange may lead to the failure and damage of the bushings. |

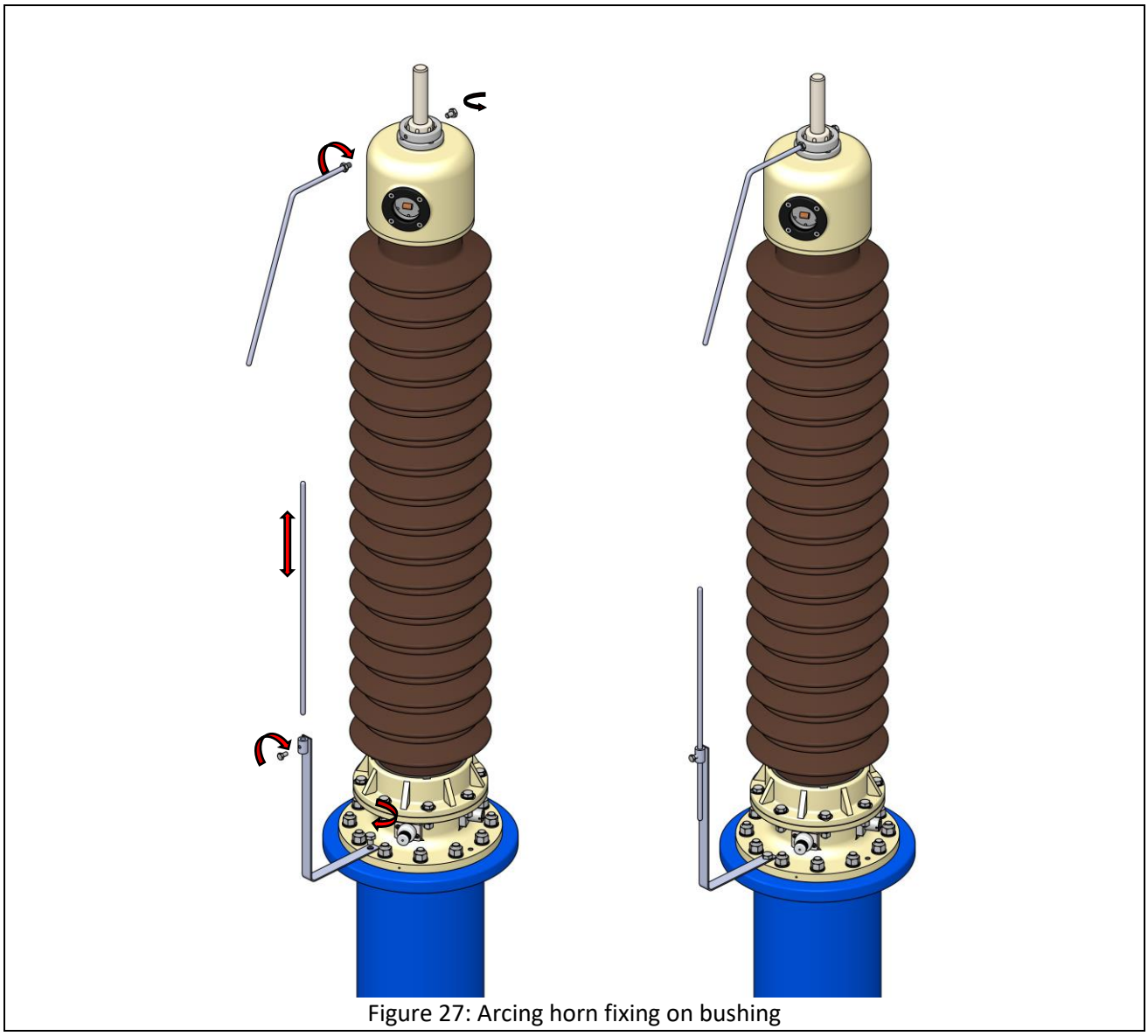


Figure 27: Arcing horn fixing on bushing

Adjust the arcing distance of arcing horns by adjusting position of lower part of the arcing horn and tighten the screw in order to secure its position.

The gap to be adjusted on the basis of Site condition coordinated with Lightning Arrestor and Basic Insulation Level of Bushing and Transformer.

| | |
|---|---|
| | **Hint** YASH recommends not to use Arcing horns on Bushings. |

## 4.8 AIR RELEASE

After connecting the Bushing with transformer lead and completing the mounting of Bushing, fill oil in transformer under vacuum upto bushing mounting flange level.

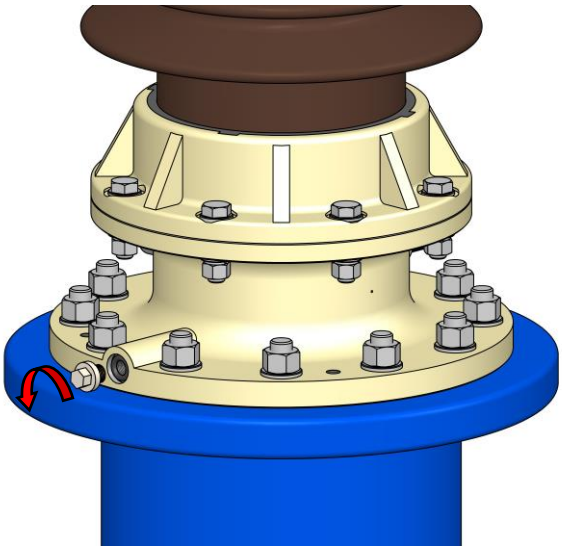


Figure 28: Air release plug details

| | |
|---|---|
| | **Hint** The size and location o-ring between the transformer turret cover and the bushing flange shall be selected so as path for Air release from turret is not blocked. Maximum possible sealing surface area is to be followed as mentioned in Bushing GAD. |

| | |
|---|---|
| | **Hint** The sealing o-ring between the transformer and the bushing is not in scope of supply of YASH. |

| | |
|---|---|
| | **Attention** All joints of Bushings, like Flange and transformer turret, Air end terminal, Air release plug, Head electrode must be subjected to Oil leak-proofness test as referred in Section 5 |

| | |
|---|---|
| | **Attention** After a waiting time of **12 to 18 hours** repeated air release from transformer turret is required to avoid air bubbles on the oil end of Active part / oil end electrode which can cause flashovers or partial discharges. |

| | |
|---|---|
| | **Attention** Recommended minimum oil level inside turret tank is upto Bushing flange level. |

# 5 COMMISSIONING

## 5.1 CHECKS BEFORE ENERGIZING BUSHING

| | |
|---|---|
|  | **Caution** Before charging bushing, the test tap cap must be closed tightly with O-ring.<br><br>If test tap cap is not closed effectively, this will result in the outermost layer of condenser core not connected to earth or will be floating and high voltages will appear across test tap and mounting flange & will cause flashover between test tap stem and mounting flange & can lead to bushing failure. |

| | |
|---|---|
|  | **Attention** Fasten the flange to the transformer/turret cover and firmly connect the flange to earth potential using earthing cable.<br>**Check earthing!** Inadequate earthing may lead to total failure of the system/damage to the bushings! |

1. Adequate and firm Earthing of Bushing Flange

2. Verification of leak proofness at Sealing joint between Mounting Flange and Transformer Tank and at air release plug on mounting flange.

3. Verification of leak proofness at the terminal cover, conservator and air end terminal sealing of the bushing.

4. Repeated Air release from Bushing's Air release plug after waiting time of 12 to 18 hours of Bushing installation.

5. Minimum immersion of oil end of Bushing in Oil: upto Bushing Flange level.

6. Capacitance (C1) and Tan Delta (C1) measurement of the Bushing.

7. Transformer winding resistance to evaluate firm contact in all current-carrying joints of Bushing and transformer lead.

8. Verification of Oil level in Bushing Oil indicator. The Oil presence should be clearly visible inside the Oil level indicator.

| | |
|---|---|
|  | **Caution** Bushing test tap cap must be closed after measurement of tan delta and capacitance |

| | |
|---|---|
|  | **Attention** The test tap may only be used if the power supply is disconnected from HV terminal. Use of O ring on test tap cap is must to avoid ingress of moisture on test tap insulation. |

## 5.2 RECOMMENDED TEST BEFORE ENERGIZING

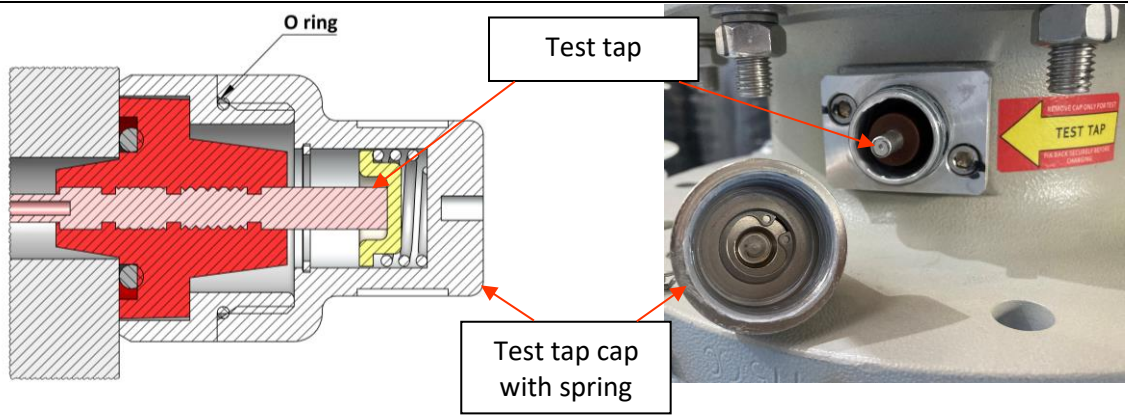



Figure 29: Test tap detail

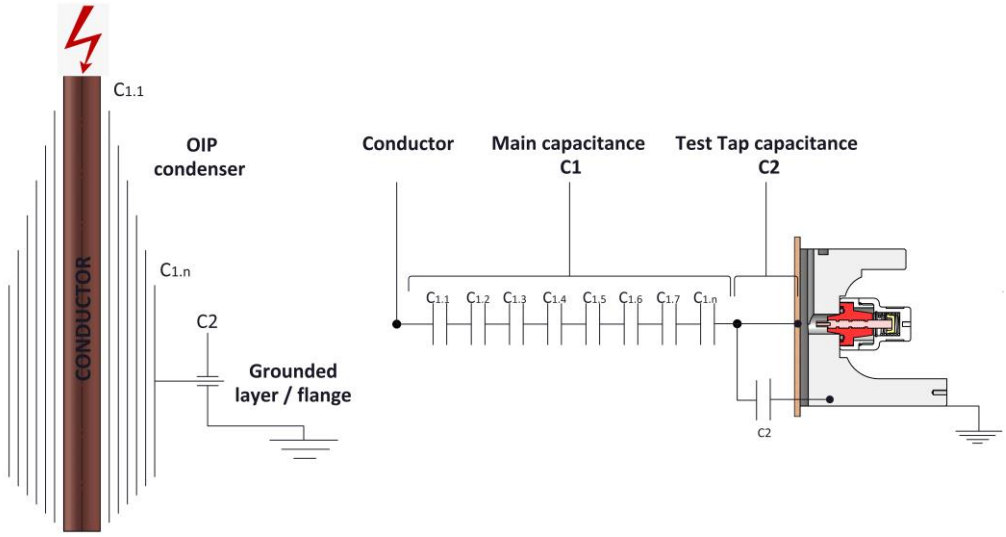



Figure 30: Principle of functioning - Capacitance and Tan Delta Configuration

### 5.2.1 CAPACITANCES C1 AND C2

**Attention** If the Bushing Tan delta or capacitance or both shows increasing trend, then YASH must be contacted for further analysis and action.

Bushing must be removed from service if the tan δ1 is above 0.7% or if the capacitance Change is more than below specified limits under the same test conditions.
**Contact YASH for further advise.**

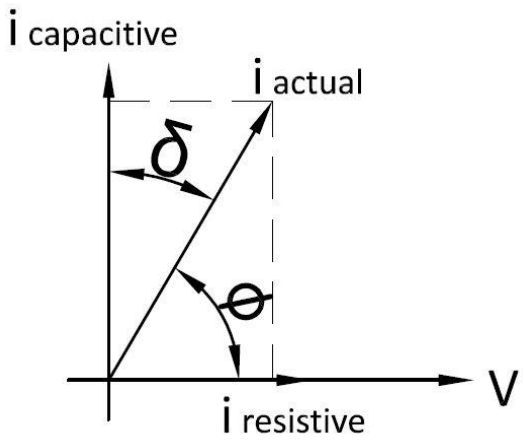
| Rated voltage | Permissible maximum Change in Capacitance |
|---|---|
| 24 kV | 12 % |
| 36 kV | 10 % |
| 52 kV | 7 % |
| 72.5 kV | 5 % |
| 100 kV | 4 % |
| 123 kV | 3 % |
| 145 kV | 2.5 % |
| 170 kV | 2.5 % |
| 245 kV | 1.7 % |

The capacitance is characterised by the geometry of the active part, position and length of the condenser layers, size of the flange, etc.)

## 5.2.2 DIELECTRIC DISSIPATION FACTOR/TAN δ1 (MAIN INSULATION – C1) & TAN δ2 (TEST TAP TO EARTH-C2)

| | |
|---|---|
| | **Hint** Bushing Capacitance-C1 is measured in UST mode and Test tap Capacitance-C2 is measured in GST mode. |

The ideal bushing insulation is a pure capacitance, but the real bushing insulation is capacitance associated with a Resistance (i.e. Dielectric Loss). The loss factor is defined by the ratio between resistive and capacitive currents of the tested part:




$$\text{Tan}\delta\ (\text{Dielectric dissipation factor}) = \frac{I_{res.}}{I_{cap.}}$$

$$\text{Power factor, Cos}\emptyset = \frac{I_{res.}}{I_{actual}}$$

Figure 31: Tan Delta / Power factor

## 5.3 PARAMETERS THAT AFFECT THE CAPACITANCE AND TAN δ

### 5.3.1 CONNECTION OF BUSHING UNDER TEST

If the Bushing is being tested, in as mounted and connected condition on transformer,

1. Firmly connect the transformer tank and ground point of Tan delta test kit to Earthing.
2. Close test tap cap of all bushings and connect the test tap to Earth. Only tan delta cap of the bushing under test shall be kept open for connection.
3. Connect and short HV Terminals of all Bushings of HV side of transformer including Neutral bushing if present. Same way connect and short HV terminals of all Bushings of LV side of transformer.
4. Failure to do so, the measured tan delta will also include transformer winding tan delta and the measured results will be erroneous.

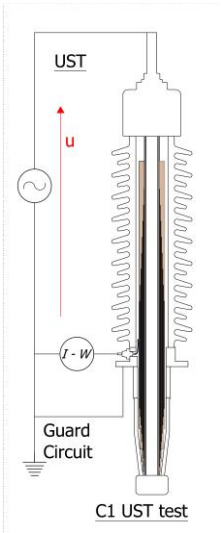



Figure 32.1

HV terminal → HV point of test kit
Test tap stem → Measurement cable of test kit
Mounting flange → HV guard circuit/ground of test kit

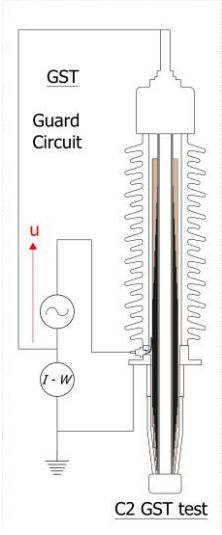



Figure 32.2

HV terminal → Measurement cable of test kit
Test tap cap → HV point of test kit
Mounting flange → Guard circuit/ground of test kit

## 5.3.2 SURFACE CONDITION OF EXTERNAL INSULATION

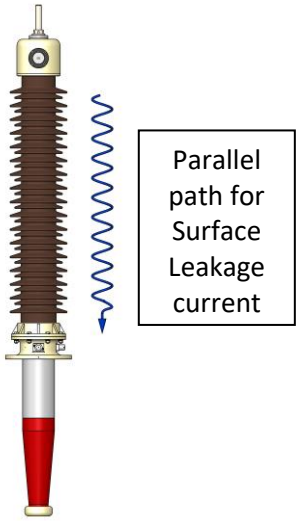



Figure 33

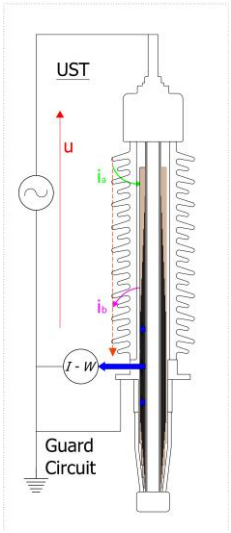



Figure 34.1

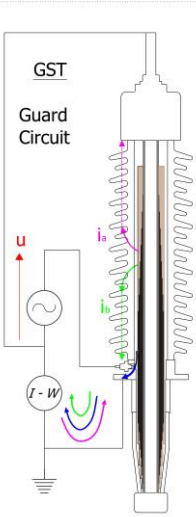



Figure 34.2

Weather condition: Tan delta shall be measured in dry and sunny weather.
External surface of Bushings (Air end insulator, Oil end Insulator and test tap) must be cleaned thoroughly to remove any foreign particles, conducting particles, dust, humidity, air pressure (altitude) etc, which may give rise to resistive leakage current flowing over the surface of insulator.

Some leakage current ia flows into the Bushing insulation under measurement and some leakage current ib flows out of the bushing insulation under measurement. The complex combination gives erroneous random results of C1 and C2 tan delta i.e. either no change or higher or lower or negative tan delta.

**Hint** To eliminate effect of Moisture and foreign particles, whole insulator surface must be cleaned thoroughly using suitable cleaning agent like acetone before start of the test. In case if the Tan delta value is higher than specified limits, it is recommended to blow hot air at approx. 60 deg C, on entire surface of Insulator to remove moisture film. Hot air blow should be steadily moved over entire insulator surface and must not be focused at a particular point to avoid damage to the bushing.

Capacitance-C1 is measured in UST mode and Test tap Capacitance-C2 is measured in GST mode.

**Hint** Capacitance-C1 is measured in UST mode and Test tap Capacitance-C2 is measured in GST mode.

### 5.3.3 EFFECT OF PARALLEL PATHS FOR RESISTIVE CURRENT

Figure 35

Bushing must be lifted atleast 1 mt. above the ground to nullify the effect of parallel path of ground currents. **In no case, measurement should be performed inside the wooden box.**

Flange shall be firmly connected to earth and should not be supported on any poor dielectric material (soggy/wet wood, …).

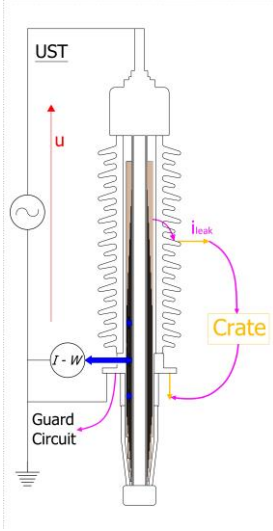



Figure 36.1

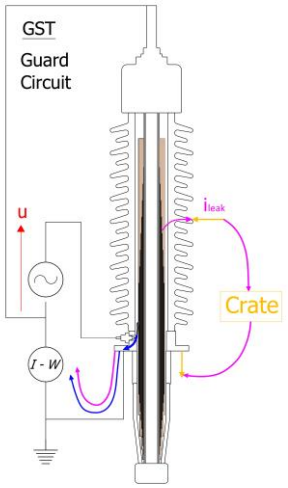



Figure 36.2

Some leakage current $i_{leak}$ flows from the parallel resistive path like wood or any other conducting path and it reduces the resistive current in the total current and hence measured tan delta value shall be erroneous.

## Acceptance criteria

**Hint** A routine test report of Bushing with test results of Capacitance and Tan delta is supplied with each Bushing and Factory test results of C1-Capacitance and Tan δ1 at 10 kV are engraved on the rating plate of Bushing.

Measurement of tan delta and capacitance must be preferably performed at ambient temperature range of 20°C. to 40°C. For better evaluation of the test results, it is advised to correct the results of tan delta and capacitance as per below correction factors.

**Correction factor for Capacitance of OIP Insulation is 0.025% per Deg Cent and rises linearly between 0 Deg Cent upto 90 Deg Cent.**
Example-1 of Correcting Capacitance value measured at 50 Deg Cent. to 20 Deg Cent.
Capacitance measured at 50 Deg. Cent. = 500pF
Capacitance corrected at 20 Deg. Cent. = 500pF − [ 500pF x 0.00025 x (50-20)]
Capacitance corrected at 20 Deg. Cent. = 500pF − 3.75pF
Capacitance corrected at 20 Deg. Cent. = 496.25pF.

Example-2 of Correcting Capacitance value measured at 10 Deg Cent. to 20 Deg Cent.
Capacitance measured at 10 Deg. Cent. = 500pF
Capacitance corrected at 20 Deg. Cent. = 500pF − [ 500pF x 0.00025 x (10-20)]
Capacitance corrected at 20 Deg. Cent. = 500pF + 1.25pF
Capacitance corrected at 20 Deg. Cent. = 501.25pF.

**CORRECTION FACTOR FOR TAN DELTA**

| Temperature Range in Deg. Cent. | Correction Factor for 20 Deg.Cent. | Temperature Range in Deg. Cent. | Correction Factor for 20 Deg.Cent. |
|---|---|---|---|
| 2-7 | 0.85 | 48-52 | 1.3 |
| 8-12 | 0.9 | 53-57 | 1.35 |
| 13-17 | 0.95 | 58-62 | 1.4 |
| **18-22** | **1** | 63-67 | 1.45 |
| 23-27 | 1.05 | 68-72 | 1.5 |
| 28-32 | 1.1 | 73-77 | 1.55 |
| 33-37 | 1.15 | 78-82 | 1.6 |
| 38-42 | 1.2 | 83-87 | 1.65 |
| 43-47 | 1.25 | 88-92 | 1.7 |

**Attention** In case of variation in test results, to remove external moisture, it is suggested to apply hot air through blower in case of test values out of limit.

| | |
|---|---|
| **Capacitance $C_1$** | should not change more than limits specified in section 5.2.1 under the same test conditions |
| **Tan Delta 1** | should be less than 0.7 % or more than double the FAT values, whichever is lower.<br><br>usually, bushings have tan delta in the range of 0.2% to 0.5% at 40°C.<br><br>increase of tan delta value more than 0.1% (0.001) per year is abnormal and bushing must be monitored closely. |
| **Capacitance $C_2$** | should be less than 10,000 pF |
| **Tan Delta 2** | should be less than 5% |

**Attention** In case the test results do not conform to above limits, YASH must be contacted for further analysis and action.

## 5.4 RELEVANCE OF TAN δ 2

- In operation, outermost foil is connected to earth through test tap cap so that C2 is shorted: hence in service there are;
    - No dielectric losses
    - No dielectric stresses
    - No partial discharge activity
- Hence it is recommended not to use tan δ2 for bushing diagnostic purposes because this parameter is highly dependent on stray effects of bushing current transformer, turret size etc.

## 5.5 RELEVANCE OF INSULATION RESISTANCE AND POLARIZATION INDEX

Insulation Resistance (IR) measurement are carried out by applying a DC voltage (Usually > 2,500 Volts) and measuring Current & thereby arriving at Insulation Resistance. There are mainly three components of current, namely 1. Capacitance Charging Current, 2. Absorption Current, 3. Leakage current. Higher IR Value essentially means measurement of lower current in fractions of Nano Amperes & thereby assessment of IR Value is highly sensitive. The measured IR is not only decided by Internal Insulation but is significantly affected by external surface leakage currents. This measurement of currents fractions of Nano Amperes results into measurement and assessment issue, and hence we should not rely on absolute values of IR and no limits can be defined on it.

Polarisation Index (PI): = IR value after 10 minutes / IR value after 1 minute

PI is carried out as it is a ratio-metric test, and which can predict insulation system performance even if the Capacitance Charging current has not gone down to Zero.

As can be seen, Bushing forms one Capacitance which is in parallel to the several Capacitances formed inside the Transformer. Since Bushing's C1 is formed by Well Defined Solid Insulation, the IR Value of the stand-alone Bushing will be higher than other components inside Transformer, however, when measured as mounted on Transformer, with several Internal Capacitances of Transformer in parallel the IR value will be lesser than standalone Bushing. Similarly, PI values will be ~1.0 to 1.1 even when the Bushings are healthy. Thus IR & PI are not specified as routine / special tests for Bushings.

We do not recommend IR & PI for assessing & judging the Bushing Quality. We recommend measurement of Capacitance (of C1) & Tan Delta (of C1) and assess Bushing Quality based on these measurements.

## 5.6 WAITING TIME BEFORE ENERGIZING

Before commissioning/energizing the bushing, Bushing must be kept in vertical position/or position in which bushing is designed for its routine operation atleast for 12 hours if the storage period including transportation is 1 month or lower; however, in case of longer than 1-month storage period including transportation, bushing must be re-kept in vertical position/or position in which bushing is designed for its routine operation for a minimum 48 hours prior energizing.

# 6 MAINTENANCE

## 6.1 RECOMMENDED MAINTENANCE AND SUPERVISION

Bushings are practically maintenance free. Though, following checks are recommended every 12 months:

**Caution** Do not work on systems that might be under High voltage!

### 6.1.1 MEASUREMENT OF CAPACITANCE AND TAN DELTA

It is recommended to perform Capacitance and tan delta measurement at interval of six months for the first year and subsequent measurements shall be done atleast once every year. (See section 5).

### 6.1.2 THERMOGRAPHY AT AIR END CONDITIONS

**Attention** All OIP Bushings have Class-A insulation, and hence maximum permissible temperature on any part of bushing is 105° C.

At maximum rated current, the bushing temperature is about 40 to 50 °C above the ambient air. Significantly higher temperatures, especially at lower current loading, can be a sign of bad connections.

Irregularities of temperature along the outdoor insulator length, metal parts (including test tap cap) have to be examined more closely. If necessary, contact YASH.

### 6.1.3 CHECK FOR OIL LEVEL AND OIL LEAKAGE

It is recommended to visually check Bushing Oil level atleast once every week. The Oil presence should be clearly visible inside the Oil level indicator.

**Attention** Bushing must not be continued in service if the Oil level is not visible in the Oil level indicator and YASH must be informed immediately for further advice and course of Correction.

Thorough Check for Oil leakages specifically from bushing shall be performed atleast every 1 year and shall be performed immediately in case of loss of Oil level.

### 6.1.4 CLEANING OF INSULATOR SURFACE

All OIP Bushings are generally supplied with Air end Porcelain insulator having Alternating type shed profile in accordance to IEC 60815-2 having self-cleaning property. However, if required as per the site conditions, Porcelain insulators can be cleaned manually Offline and by High pressure water jet in Hotline condition.

**Caution** Manual cleaning of Bushing must not be performed when the System is charged. Safety rules of principle company must be followed.

**Caution** For Hotline washing, norms of Principle company must be followed specifically for distance from live object, Pressure of water spray and its variation, Movement of water jet along the product, resistivity of water used for cleaning.

## 6.2 REPACKING OF BUSHING

The bushings and supplied accessories should be repacked and stored/transported in original packing box maintaining the original packing scheme as delivered from manufacturer's premises.

**Caution** The PU foam support should be fixed in such a way that bushing does not move axially or sideways.

# 7 DISPOSAL AND ENVIRONMENTAL INFORMATION

## 7.1 OVERVIEW

**Attention** Sort other materials and send them to an approved environmental waste treatment plant. All parts of Bushing must be recycled in such a way to avoid soil & water pollution.

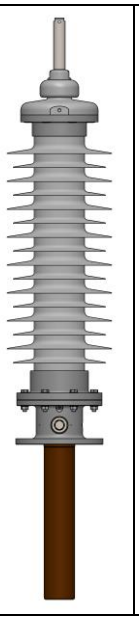
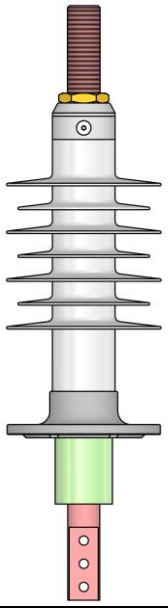
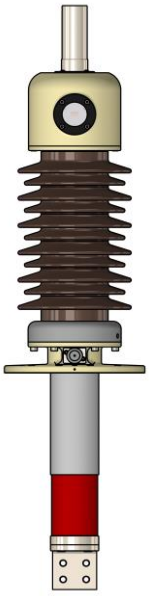
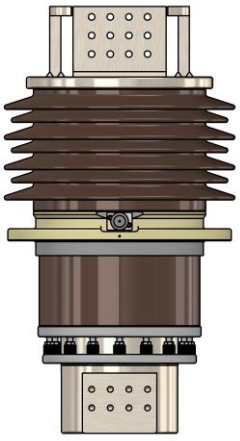
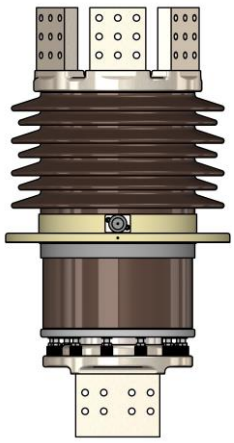
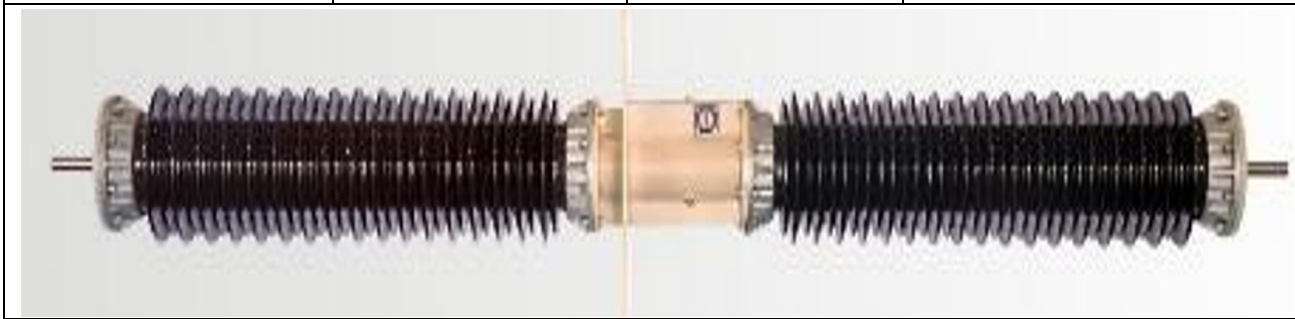
## 7.2 DISPOSAL AT THE END OF LIFE-TIME

**The bushings are made with following components.**

- Central tube or conductor is made of either aluminium or copper.
- Active part is composed of Oil impregnated paper with aluminium foils.
- Flange, Flange extension, Electrode and Bushing conservator are made of aluminium.
- Insulator is composed of porcelain.
- Thimble, split conductor, and terminal are made of copper or brass.
- Screws, bolts, pins, washer, fasteners are made of steel.
- Transformer oil according to IEC60296.
- Oil level indicator is made of Polycarbonate and Cork float.
- Gaskets and O-rings are made of Fluorocarbon or Fluoro-silicon rubber.

## 8. NOTES

## DISTINGUISHED PRODUCT RANGE

<table>
<tr>
<td>  </td>
<td>  </td>
<td>  </td>
<td>  </td>
</tr>
<tr>
<td>RIS/RIP bushings with Polymer/Porcelain housing upto 245 kV</td>
<td>LV Oil Insulated Polymer Bushings upto 36kV 3150 Amp</td>
<td>LV OIP bushings Upto 4000 Amp</td>
<td>Retrofit/Replacement of reputed make bushings</td>
</tr>
<tr>
<td>  </td>
<td>  </td>
<td>  </td>
<td>  </td>
</tr>
<tr>
<td>Oil filled High-current bushings Upto 16000 Amps</td>
<td>OIP High-current bushings Upto 20000 Amps</td>
<td>Retrofit High-current bushings</td>
<td>Oil TO Oil OIP bushings Upto 245 kV</td>
</tr>
<tr>
<td colspan="4">  </td>
</tr>
<tr>
<td colspan="4">OIP and RIP wall bushings upto 245 kV</td>
</tr>
</table>

**YASH HIGHVOLTAGE LTD.**
P.O. KHAKHARIYA,
SAVLI, VADODARA
GUJARAT, INDIA
Phone.: +91 90 99 096 577/+91 90 99 086 467
sales@yashhv.com / services@yashhv.com
www.yashhv.com