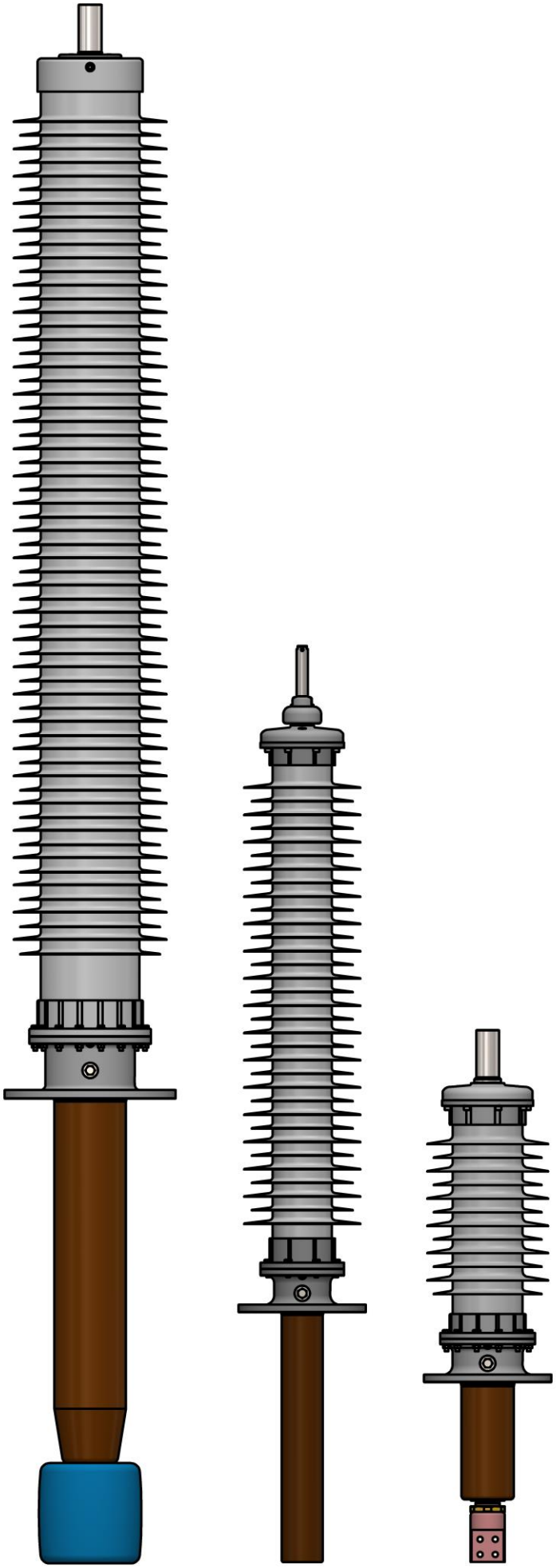


INSTALLATION, OPERATION, MAINTENANCE INSTRUCTIONS

RIP BUSHINGS UPTO 245 KV

Content

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.

1.1. 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 etc.)
	**FAILURE TO COMPLY WITH SAFETY RULES CAN BE FATAL AND CAN CAUSE DEATH!** 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 terminal and Earth
	Strong electromagnetic fields can be present nearer to the bushings. People with pacemakers should not go near the energized bushings! Sensitive technical devices must be protected by appropriate measures.

1.2. STORAGE AND TRANSPORTATION

	Bushings must be always protected from Direct exposure to rains / atmospheric moisture and humidity.
	**Attention** Adequate measures must be taken to avoid rodent/monkey bite. Always ensure that, Bushings are packed in its original packing box to protect Silicon rubber sheds from rodents. Bushings with damaged Silicon rubber sheds must not be used without consent of YASH.

Figure 1: Silicon rubber insulator damaged by rodent attack.

	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 plastic bag. Oil-side of RIP Bushing is provided with Oil Filled protection tank to protect Oil End Surface of RIP Bushing from atmospheric humidity/moisture.

Figure 2.1: Wooden Packing box

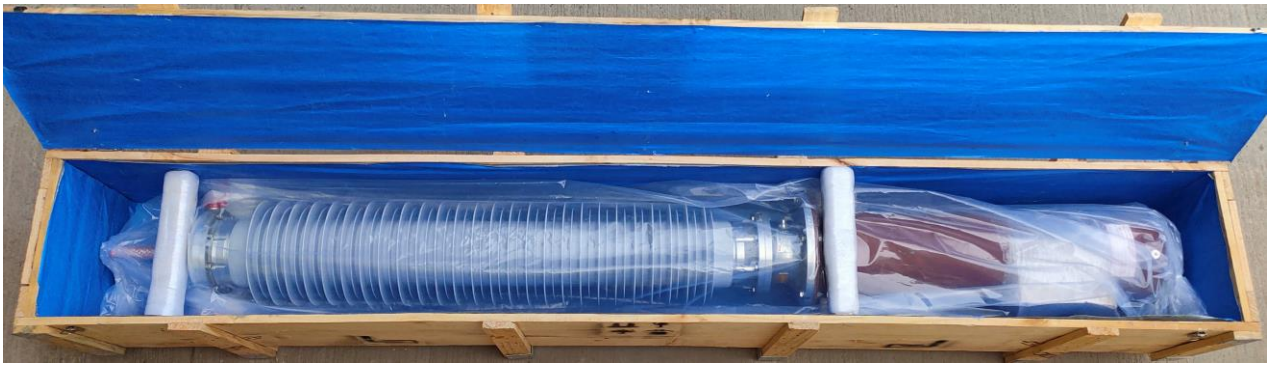
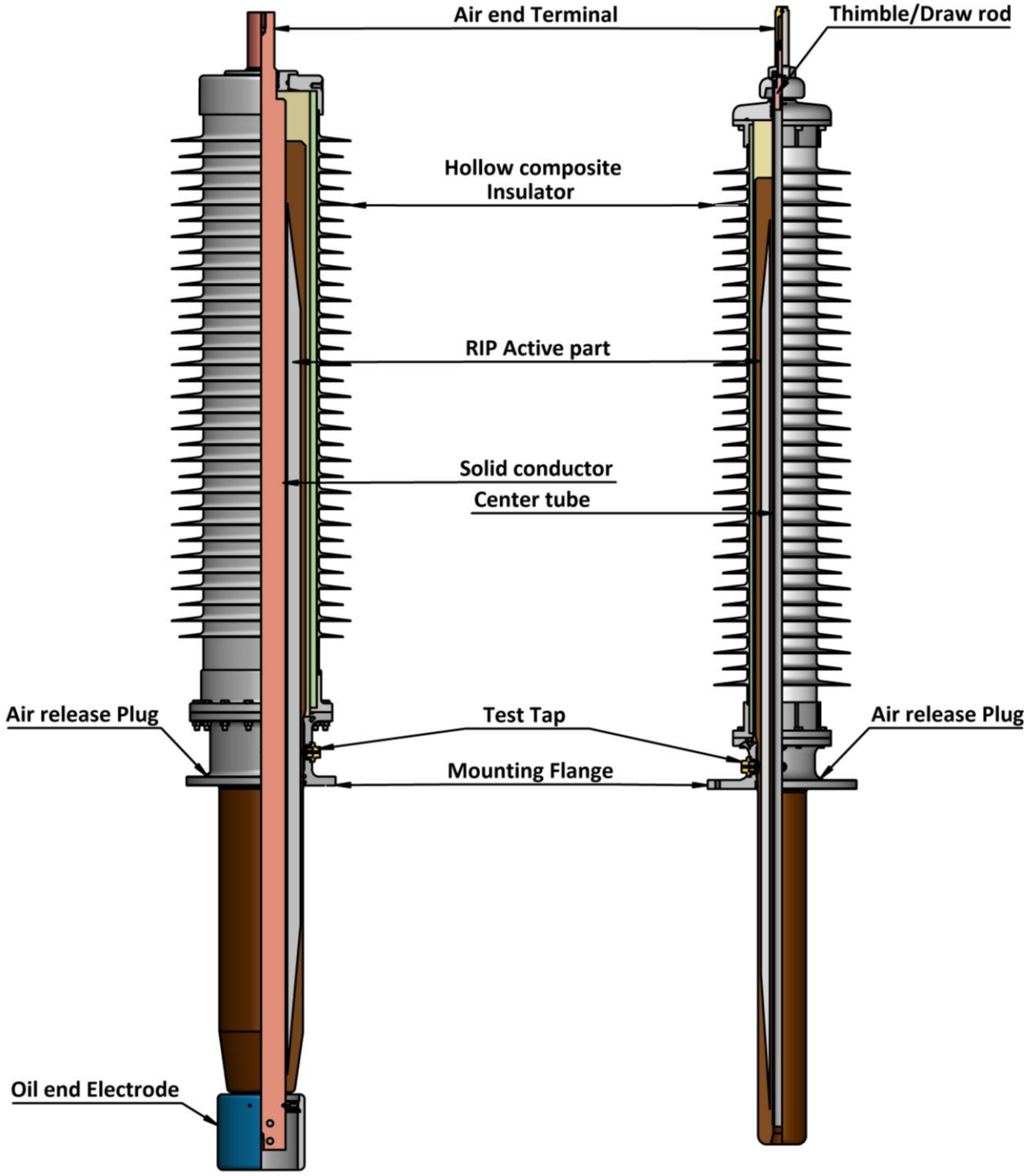


Figure 2.2:Bushing packed with plastic bag cover

Figure 3 : Oil filled protection tank

Check the packaging for any damage Immediately after receipt of the bushing at Transformer Factory / Site. Obvious damage to packing box must be informed to YASH immediately.



SOLID STEM BUSHING DRAW LEAD/DRAW ROD BUSHING

Figure 4: Bushing construction

All dry type Transformer Bushings for Oil to Air application with RIP Insulation and Composite Insulator are designed in compliance of IEC 60137. YASH make bushings are designated as below:

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

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

Based on Current rating and Connection type to the transformer winding, different available models are designated as **VRL, VRD, VRS.**

Design description:

RIP transformer bushings are practically maintenance-free.

The insulation of dry type transformer bushing is RIP. Insulating paper is wound 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 epoxy resin to form the Active part. The active part is subsequently machined as per the final dimension requirements.

Followed by this, mounting flange is bonded on Active part using special electrically insulating epoxy-based adhesive. Epoxy Test tap is formed while bonding the Mounting flange.

Hollow composite Insulator with FRP tube and Silicon rubber shed housing is assembled on the air side of the Active part and thus covering the air side of the Active part. The annular space between Active part and hollow composite insulator is filled with special dry insulating material.

The Bushings carries current through solid conductor or drawn rod/lead.

All metal parts are made of corrosion-resistant aluminium. Fasteners are of stainless steel.

The bushing is provided with test tap to enable measurement of Capacitance, Dielectric Dissipation Factor-Tan Delta / Power Factor, to monitor health of bushing.

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 90° 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. Special requirements are supplied against specific customer requirements.

4. INSTALLATION OF BUSHINGS

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

	**Attention** Silicon rubber shed must be protected from damage while lifting or storage inside packing box or resting on ground or due to abrasion or any other way. Do not attach the sling / lifting belt directly onto the silicon shed.

	**Attention** Utmost care to be taken to prevent contact of any kind of Oil (Transformer Oil in Particular) with Silicon Sheds, as this will lead to permanent distortion of Shed profile & hence will cause irreversible and permanent damage to Silicon Sheds.

Silicon insulator shed deformed due to swelling as a result of contact with transformer Oil

	**Attention** Bushings with deformed Silicon rubber sheds must not be used. In case of doubt or query, contact YASH.

4.1. SUPPLY CONNDITIONS

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

 Figure 5 : Oil end of Active part of bushing	Oil side Active part of Bushing is protected from handling damage by use of PVC mesh.
 Figure 6 : Screwed Electrode with PVC cap	Screwed Electrodes which are supplied along with Bushing and inside protection tank, are protected by PVC cap.
 Figure 7 : Bayonet type electrode packing	Bayonet type electrode is protected by plastic bag wrap, packed inside Corrugated box and supplied separately inside bushing packing box.

Figure 8 : Terminal Protection

HV terminals of Bushings are provided with PVC mesh to protect from transport damage.

4.2. UNPACKING AND REMOVING BUSHING FROM PACKING BOX

Attention Do not use cutting tools to cut-open the bubble wrap or protection cover on terminal/electrode. as they might damage the insulating coating or electro-plated surfaces.

Attention Do not use cutting tools to remove the protection foil as they might damage the silicon sheds.

Remove Plastic bag from Bushing and preserve it, so that it can be used for repacking of Bushing.

All bushings are equipped with swivel eye bolt on Bushing head to lift and takeout from the packing box. Swivel Eye Bolts are provided for handling purposes and should be removed before connecting Bushing to HV System.

Light weight bushing can be taken out of the wooden box by hand.
Heavier bushing should be lifted from the Wooden packing Box using Swivel eyebolt and Eye bolt/D-shackle (Eye bolt and D-shackles are not part of supply).

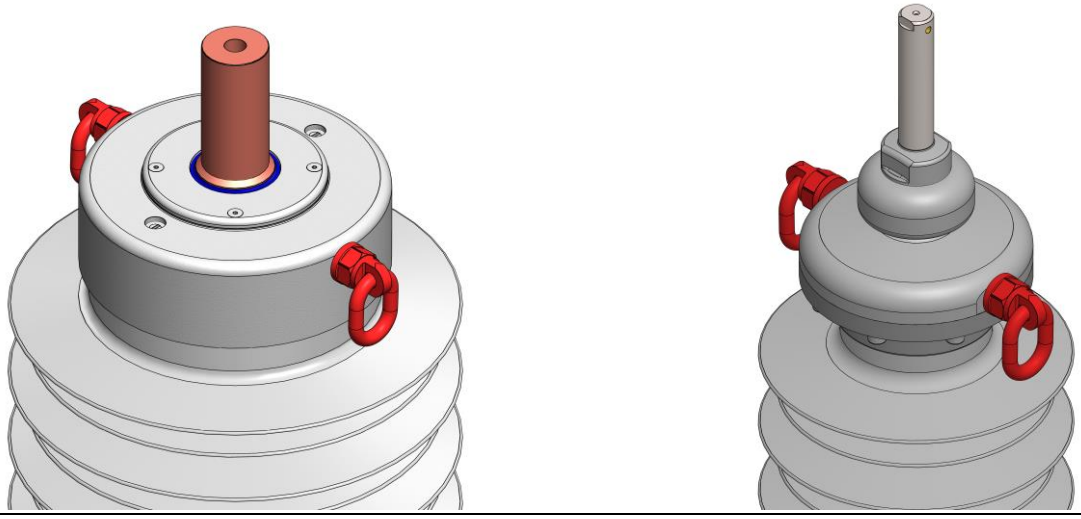


Figure 9: Fixing of Swivel eye bolt on top cap

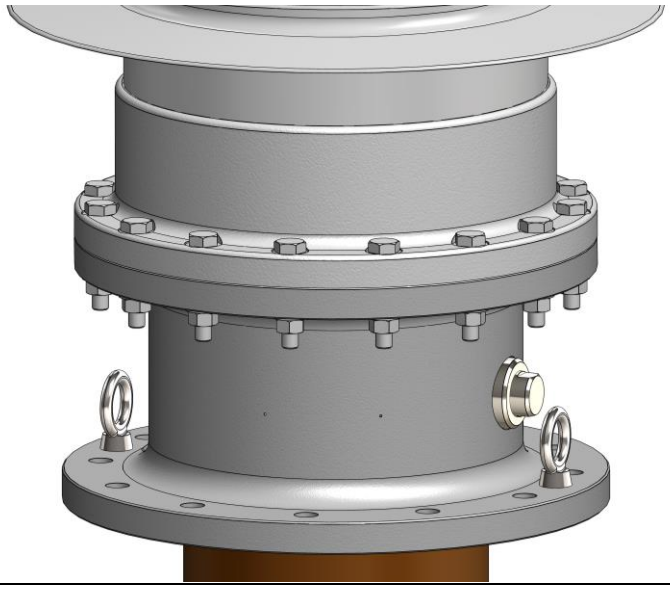


Figure 10: Fixing of Eyebolt on mounting flange (Eye bolts are not part of supply)

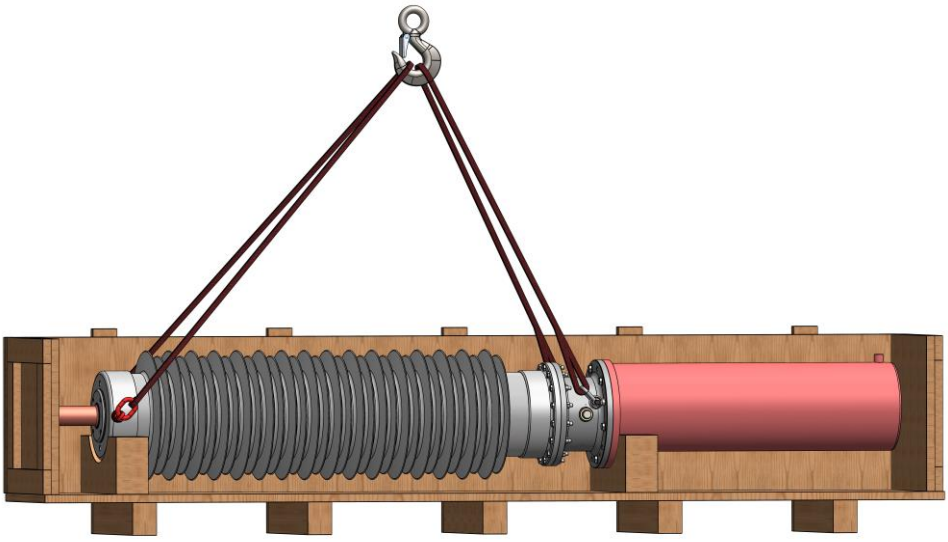


Figure 11:Lifting of bushing from box

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. Avoid use of metal slings to prevent damage to the Bushing. Place the bushing outside of wooden packing box on supports/protection pad, so that silicon rubber sheds do not touch the ground causing its Permanent deformation.

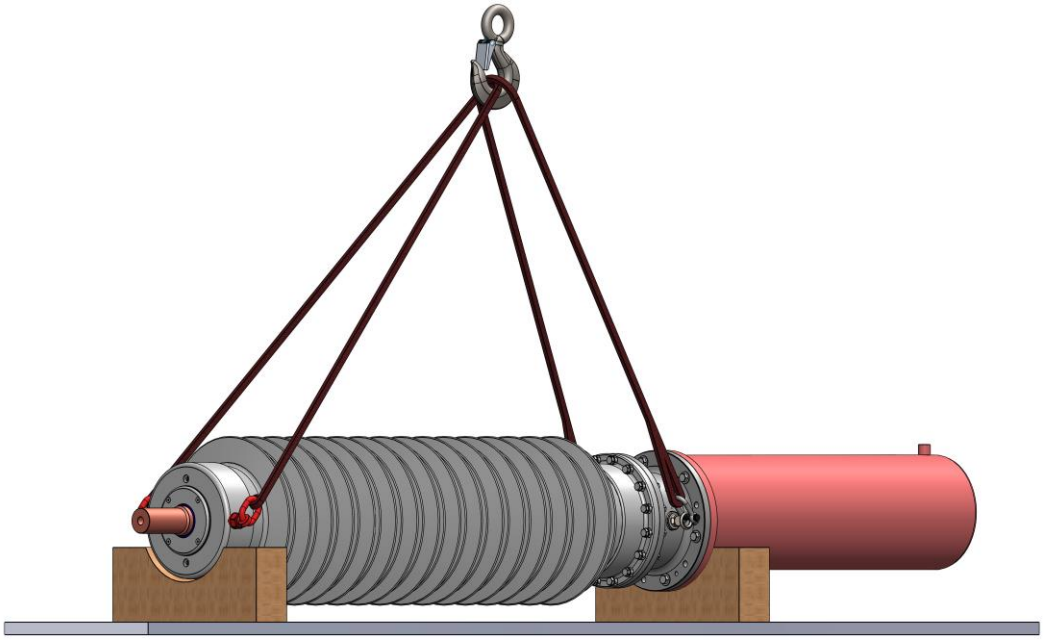


Figure 12: Bushing on protection pad

Attention Resting bushing on floor with support of Silicon rubber shed may lead to permanent deformation and damage of the sheds.

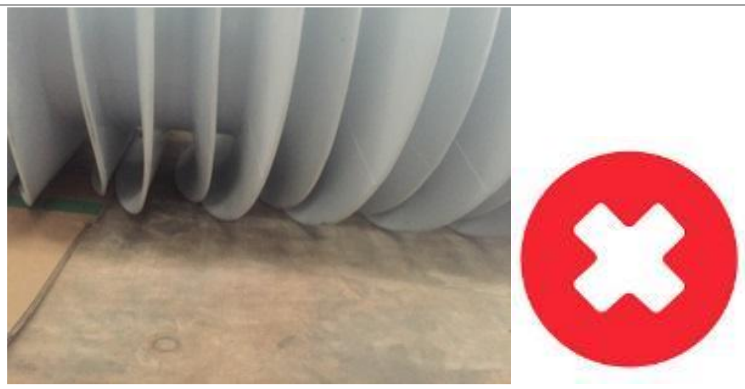


Figure 13: Bushing as supported on Silicon rubber shed

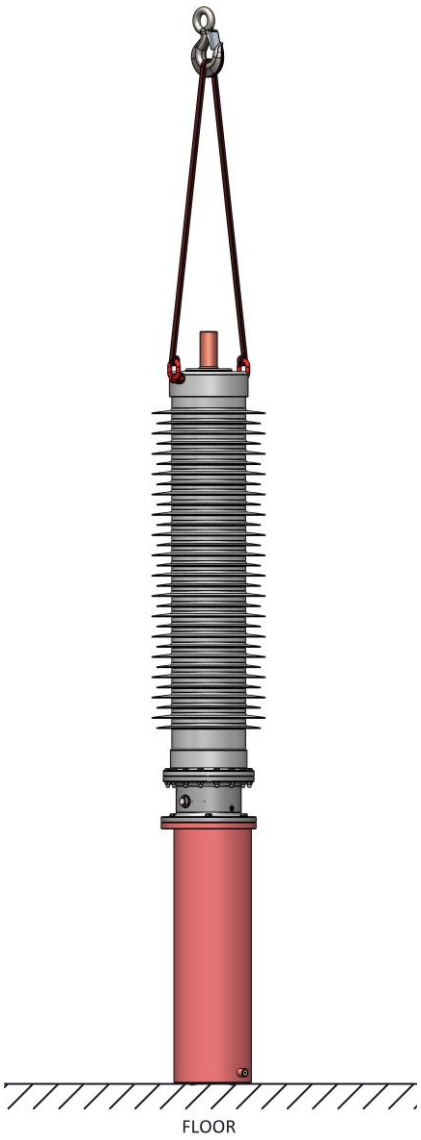


Figure 14: Rest bushing vertically on hard floor to remove protection tank, while ensuring bushing is engaged in crane Hook.

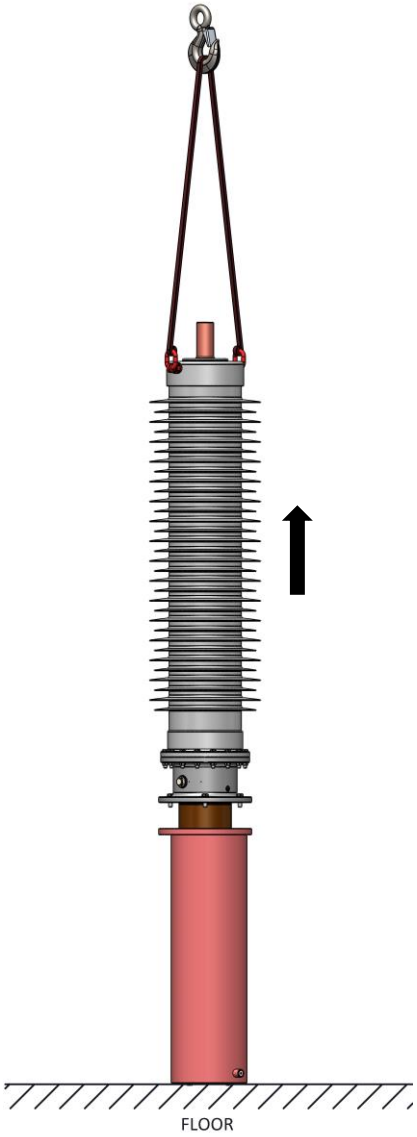


Figure 15: Remove protection tank from bushing

- Make the Bushing from horizontal to vertical and rest on ground with the support of protection tank. Keep the Bushing tied/engaged in crane to avoid possibility of falling down.
- Remove all fasteners of the tank and detach the tank from Bushing. Lift the Bushing vertically up, taking out the oil end of Bushing from protection tank.
- Wipe the Oil end side of Bushing thoroughly using oil absorbent paper and acetone. Ensure thorough cleaning of the Bushing Oil end side and Flange sealing surface so as dust particles, foreign particles, and moisture, if any, are removed.
- Close the protection tank with a cover plate (Not supplied by YASH) and O-ring seal. (O-ring is supplied with protection tank and generally the transformer turret cover plate can be directly used as cover plate for sealing of protection tank). The sealing has to be adequate enough so as to avoid contamination of Oil due to dust, foreign particles, moisture etc. This procedure is necessary at Transformer factory and at field if the bushing is to be stored with the same oil in the protection tank.

	Use of Oil absorbent paper is recommended to wipe clean the oil on surface of Bushing after removal of protection tank

	**Attention** Bushings should not be stored vertically while supporting on Protection Tank Bottom resting on ground.

	**Attention** After testing and using the Bushing, fix back the Protection tank on Oil side of Bushing as per Repacking section of this manual immediately. It is highly recommended to carryout refiltration of Oil before filling in the tank (after assembly on bushing), before dispatching bushing from Transformer Factory.

	**Attention** Prolonged exposure (More than 24 hours) of RIP active part (Transformer side of Bushing) to ambient may result in deterioration of Tan Delta value of RIP Insulation.

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

	**Attention** Relative humidity should not be more than 65% when oil end side of bushing is not covered with oil filled protection tank.

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. Protection tank shall be removed from Bushing before installation of the bushing on transformer.

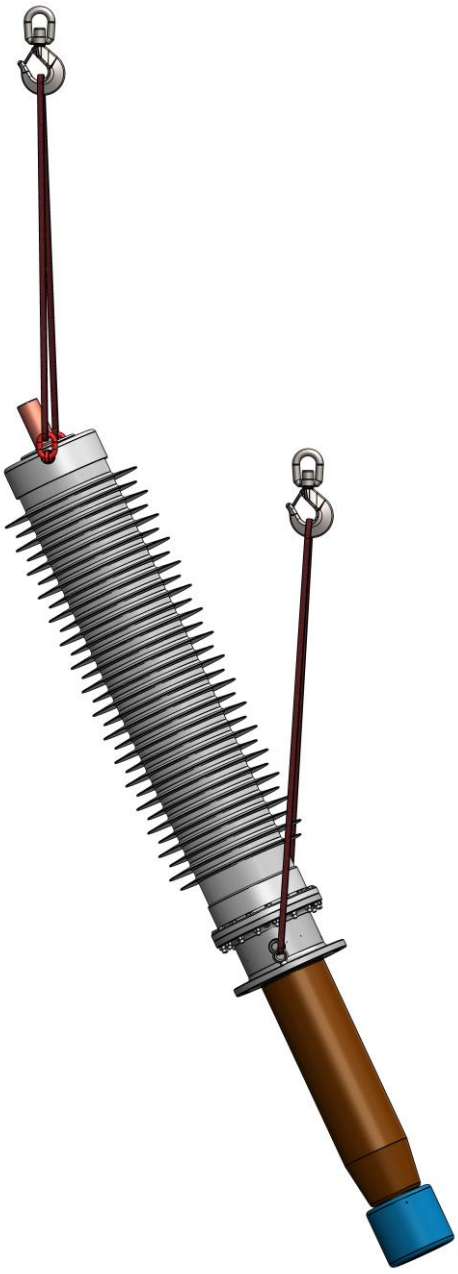


Figure 16: Bushing lifting with two cranes

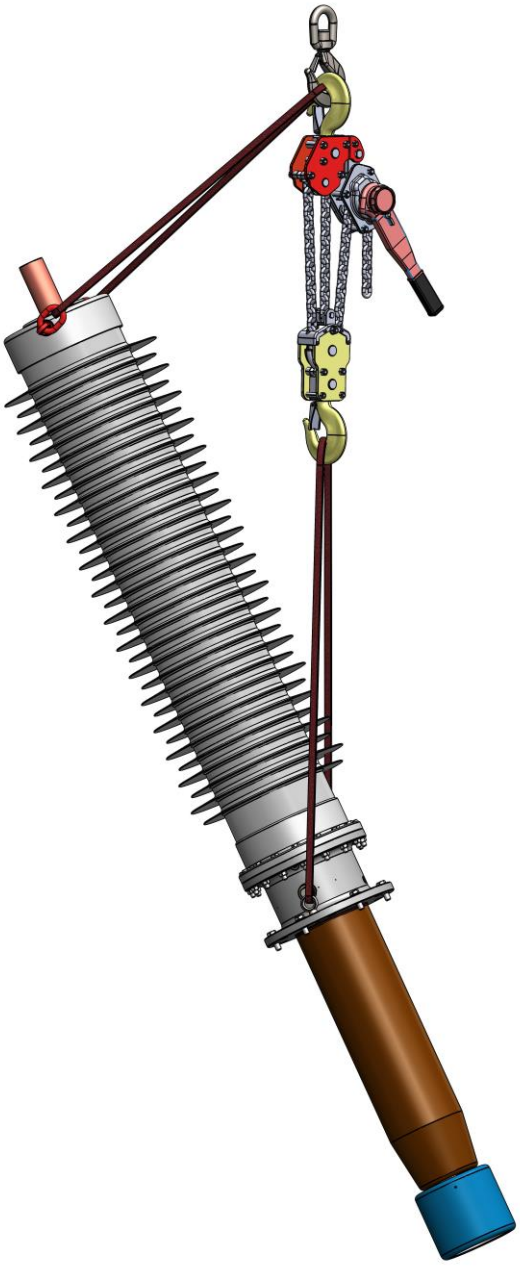


Figure 17: Bushing lifting with one crane & hand winch

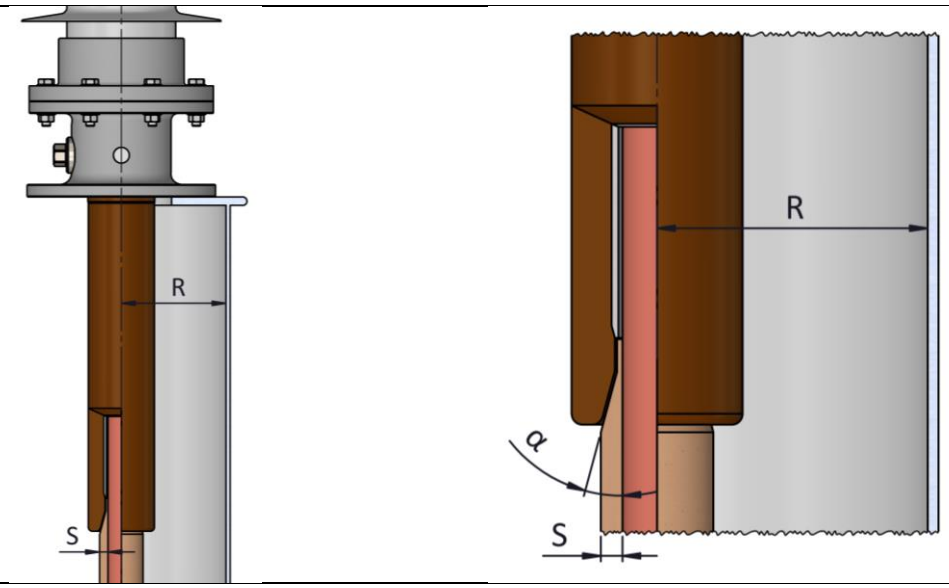
4.5. PROCEDURE OF CONNECTING TRASNFORMER WINDING LEAD

4.5.1 CONNECTION OF DRAW LEAD / SPLIT DRAW ROD TYPE BUSHINGS

	Attention Keep the O-rings on 'thimble lock-nut' and 'Electrode-head' in same position and do not remove O-ring-1 and O-ring-2 to prevent damage or loss.

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

	Attention Draw lead type bushings are despatched with transport bolt attached to air end terminal, which should be detached before connecting the thimble. (see Figure 20)

	Hint
	
	Figure-18: 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 GAD. Value of 'Insulation thickness S' and a shall be chosen as per transformer manufacturer standard.

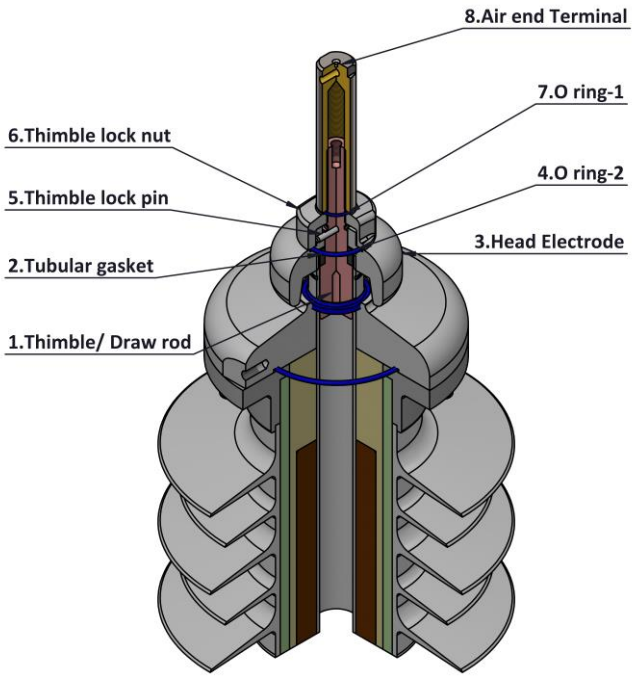


Figure 19: Bushing head detail

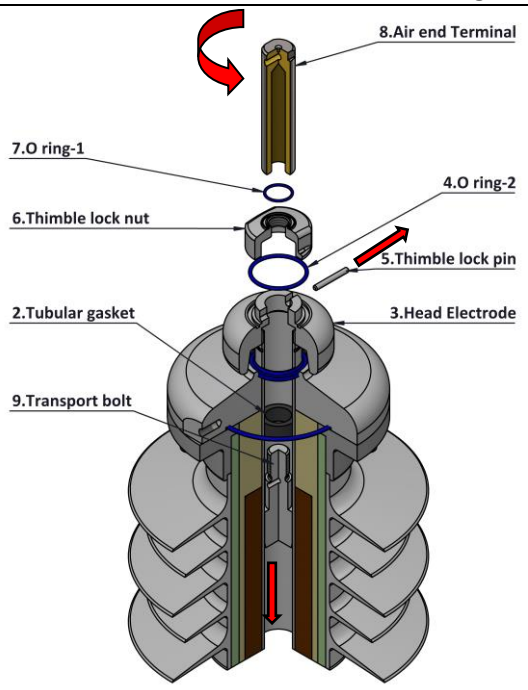


Figure 20: Remove transport bolt

1) Unscrew the 'Air end terminal' from 'Transport-bolt'
2) Remove 'thimble lock-nut' from 'Transport-bolt'
3) Remove cylindrical 'thimble lock-pin' from 'Electrode-head'
4) Take out the 'Transport-bolt' from bushing

	Retain the 'tubular gasket', 'O-ring 1' and 'O-ring 2' for later use. Head Electrode of Draw lead or Draw rod Bushings is fixed on bushing Centre tube and need not be removed to pull the Lead/rod from Bushing.

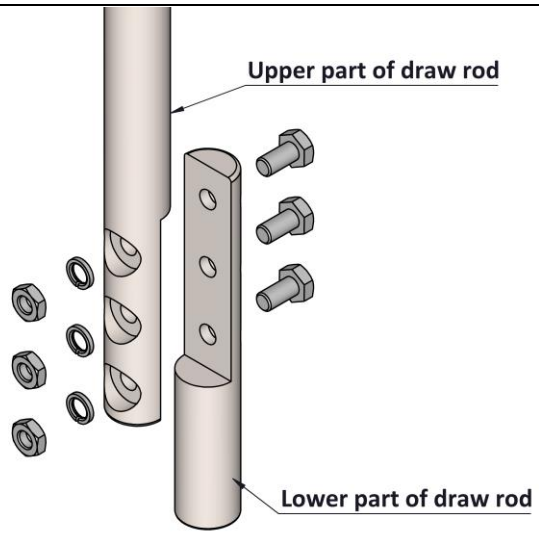


Figure 21: Split type draw rod connection

5) 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.
6) Lower part of Draw rod to be detached from upper part and to be connected to Transformer winding lead.
7) Lap joint of upper part of draw rod and bottom 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 bottom 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 bottom part of draw rod connected to transformer lead and upper part of draw rod inside Packing box.

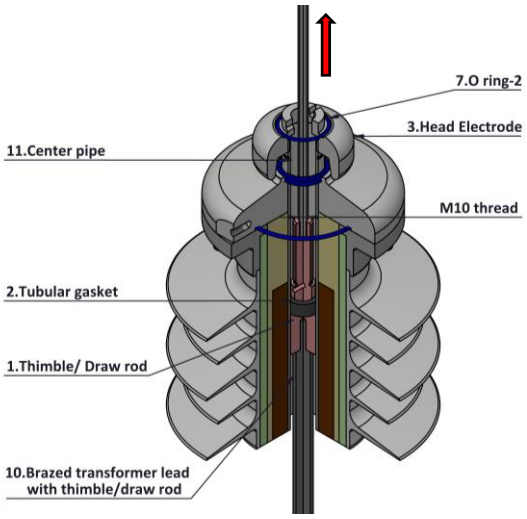


Figure 22: Pull the thimble/rod

8) 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 'head electrode using M10 bolt/rod and fixed on hole provided on top of thimble/draw-rod, while slowly lowering the bushing onto transformer.
9) Ensure proper placement of 'O-ring-2' on head electrode.

	Attention The 'tubular gasket' must be attached to copper thimble only after sufficient cooling.

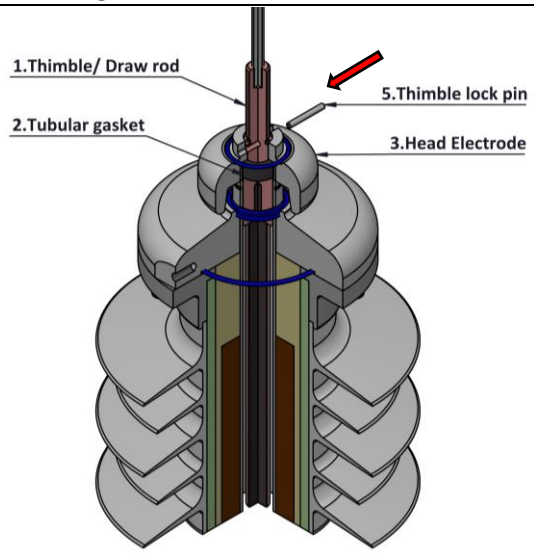


Figure 23: draw lead with Transformer lead

10) Insert 'thimble lock-pin' through hole provided in the thimble/draw rod and place the thimble/draw rod firmly by resting lock-pin on both sides in the grooves provided on 'head electrode'.
11) Remove the M10 pull through cord from thimble/draw-rod top side.
12) Hand tighten the 'head electrode' on bushing center pipe threads till it is firm.

	Attention Do not try to apply extra force or over tighten the part.

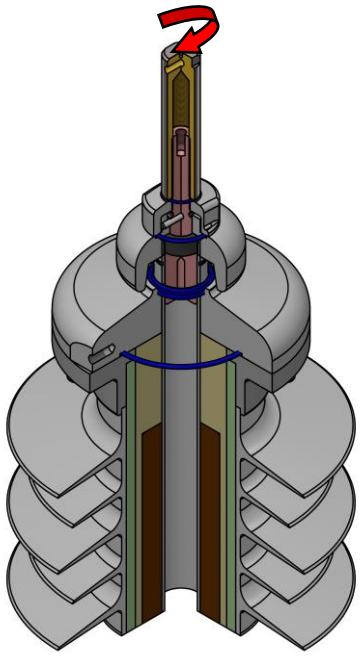


Figure 24: Terminal Tightening

13) Ensure proper placement of 'O-ring-1' on top of 'thimble lock-nut'.
14) Screw on 'thimble lock-nut' with 'thimble/draw rod' and fully tighten by hand and then after tighten it about ½ to ¾ turn using adjustable spanner.
15) Screw on 'Air end terminal' with threads of 'thimble/copper bolt/draw rod' tighten at 40 N.m torque using torque wrench.

	Caution: Use of torque wrench is must. Any over tightening can cause thread damage/thread locking.

4.5.2. 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 parts like helical springs, bolts, screws etc. need not be removed while electrode removal or refixing or during fixing of the transformer lead. (All parts are identified in Figure 27 and Figure 30.)

	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.

	Attention 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 25.1: Screwed type electrode fixed with grub screw

Figure 25.2: Screwed type electrode fixed with lock ring

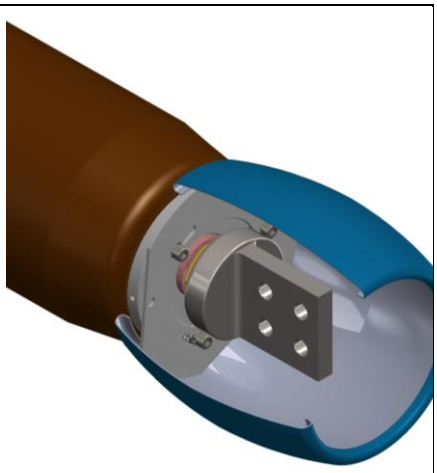
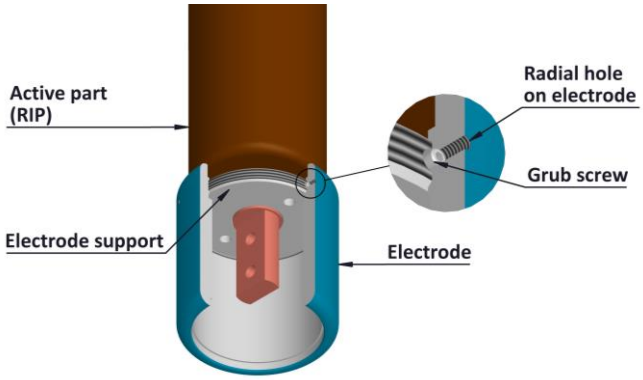


Figure 26: Bayonet type electrode

4.5.2.1. BUSHINGS WITH SCREWED ELECTRODE

Hint
Screwed type electrode fixed with lock ring is generally provided for Draw-lead type and Split Draw-rod type bushings, hence it is not required to remove this electrode while connecting the bushing with transformer lead.



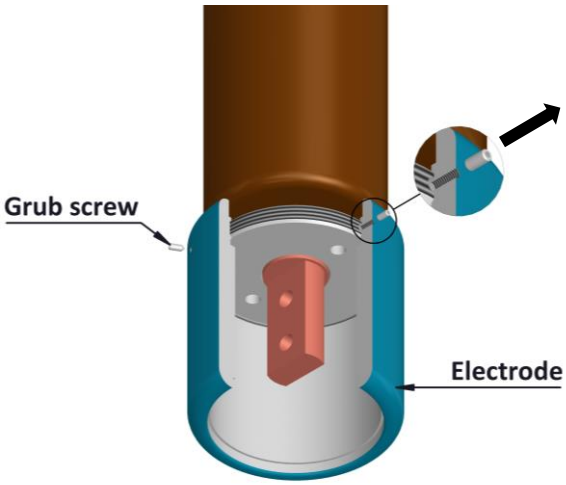


Figure 28.1: Remove screwed electrode

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

Attention
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 RIP core using Wax based pencil, this reference can be used to align the electrode while refixing the Electrode.

Figure 28.2: Unscrew and slide down screwed electrode

Attention
Remove wax pencil marking before closing manhole cover on transformer

2) Unscrew all Grub screws inserted in radial holes on Electrode' and 'Electrode-support', by around 4 to 5 turns, so its thread engagement from Electrode support is removed. Entire screw need not be removed from Electrode.
3) Unscrew the 'Electrode' from 'Electrode-Support' and slide down over transformer winding lead. Connect transformer winding lead to the bushing's oil end terminal

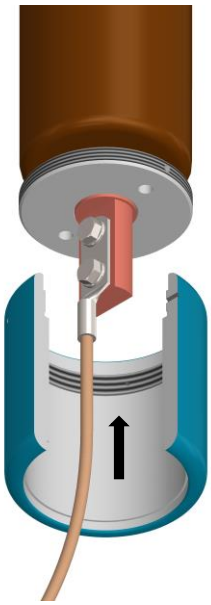


Figure 29.1: Fixing of transformer lead and Screwed electrode

STEP-2 FIX THE ELECTRODE

4) Slide up the 'Electrode' on transformer winding lead and screw it on 'Electrode-support'.
   After screwing the electrode as per the original position, align the Electrode with respect to Active part as marked earlier.
5) Fix back all three grub-screw in radial holes of 'Electrode-support' and tighten fully.

Attention
Verify proper fixing of electrode assembly. The electrode assembly must not be loose or moving or rotating.

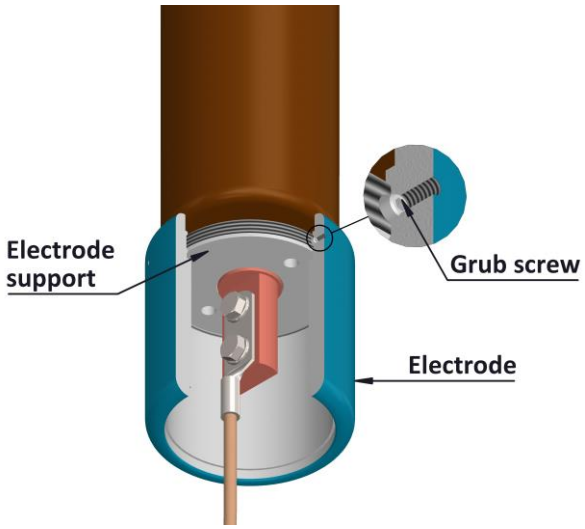


Figure 29.2: Fixing of transformer lead and Screwed electrode

4.5.2.2 BUSHINGS WITH BAYONET ELECTRODE

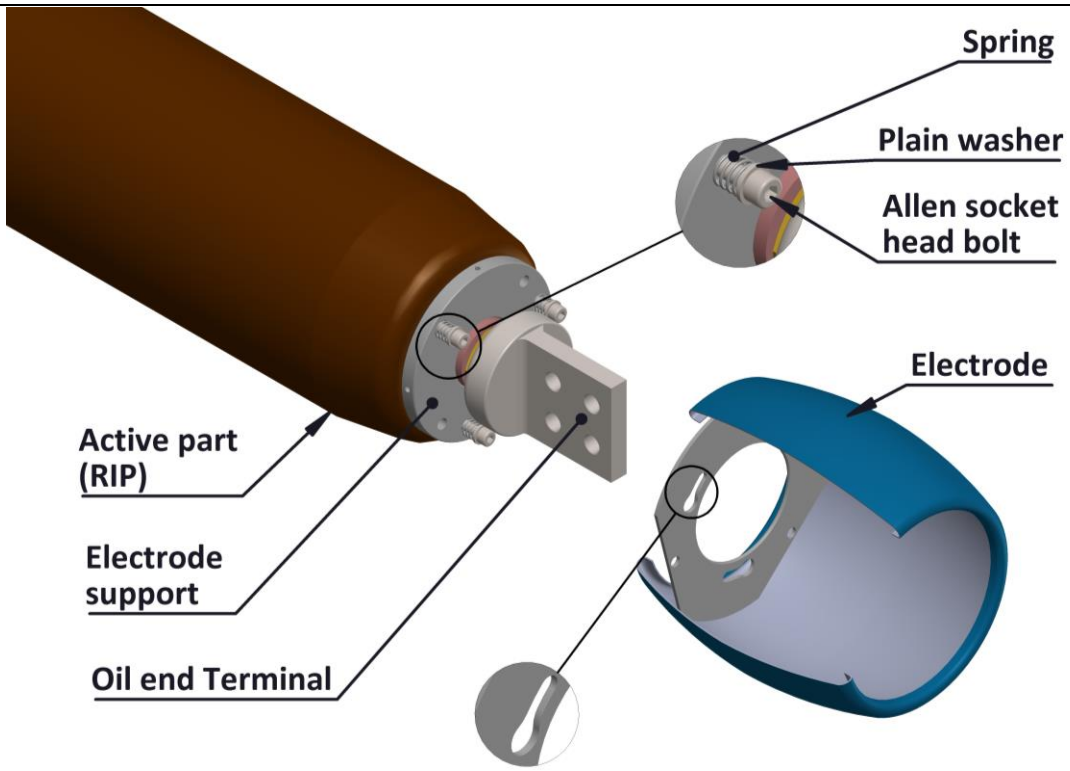


Figure 30: Bayonet electrode detail

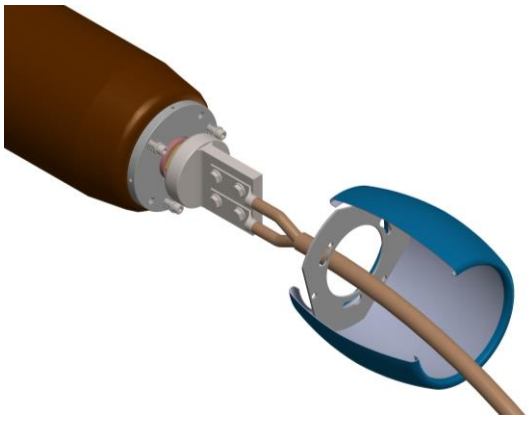


Figure 31: Fixing of transformer lead and bayonet electrode

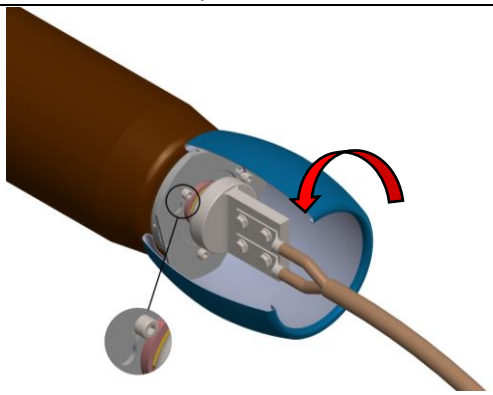


Figure 32: Fixing of transformer lead and bayonet electrode

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

1) Remove the Electrode (if present) by rotating and 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) Insert the transformer cable / lead connection through the electrode and 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 contact surfaces of the bushing are electroplated; hence do not use emery paper or any abrasive material to clean the surface.

	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.

- 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 4.5 of this manual.

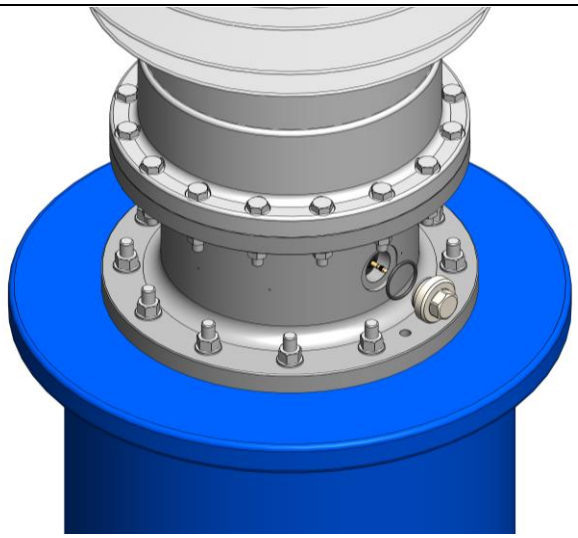


Figure 33.1: Fix test tap cap with O-ring

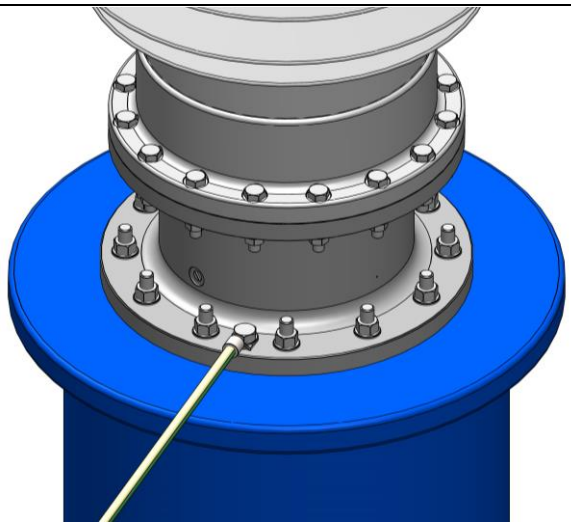


Figure 33.2: Connect earthing cable

Tighten the bolts on the flange to 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.

	Sequence of tightening the bolt must be opposite i.e. criss-cross and not adjacent to each other. Recommended tightening torque of mounting bolt for fastener shall be followed as per OEM guidelines.

	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. 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. Recommended tightening torque of test tap cap is 30Nm.

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

Inadequate earthing of flange may lead to the failure and damage of the bushings.

4.7. ACCESSORIES MOUNTING (ARCING HORN, if covered in scope of supply) AND EARTHING OF BUSHING

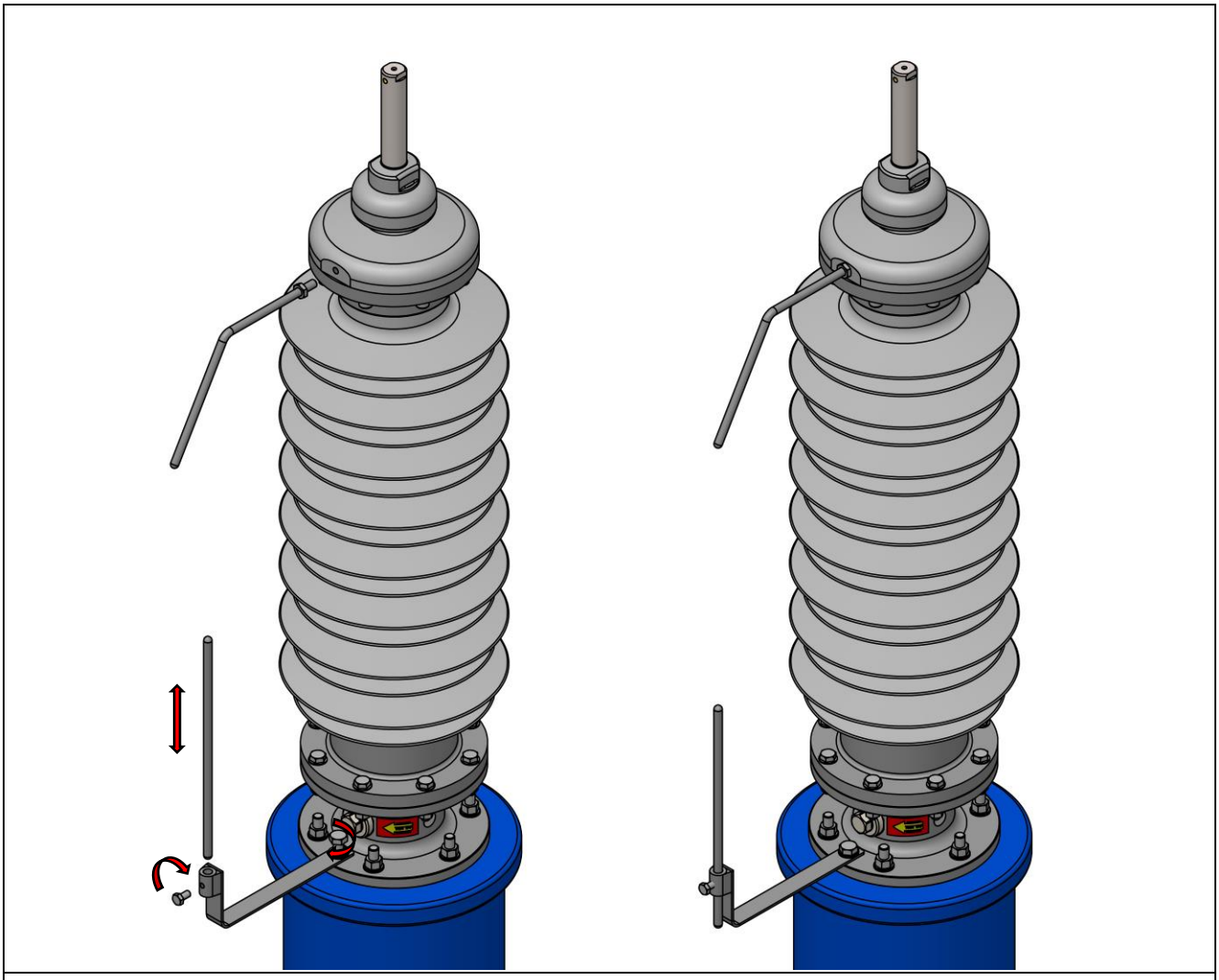


Figure 34: Arcing horn fixing on bushing

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 it.

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 on transformer. Fill oil in transformer under vacuum upto bushing mounting flange level.

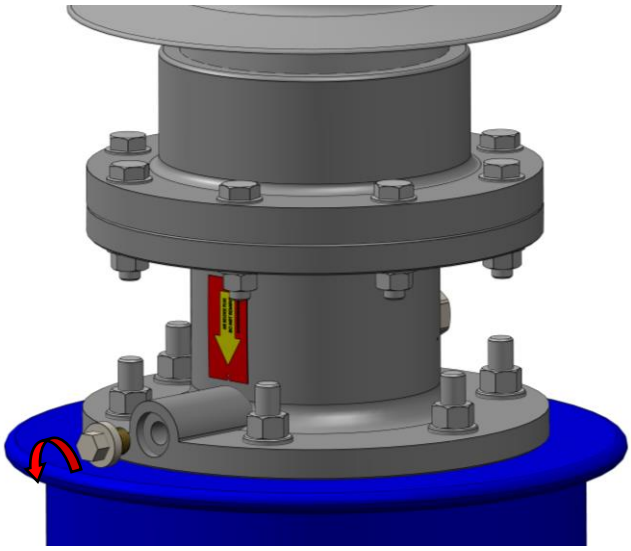


Figure-35: Procedure of releasing Air through Air release plug

	Hint The size and location of 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 per section. 5

	Attention: After a waiting time of **24 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. CHECKS TO BE PERFORMED BEFORE ENERGIZING BUSHING AT TRANSFORMER FACTORY AND AT SITE

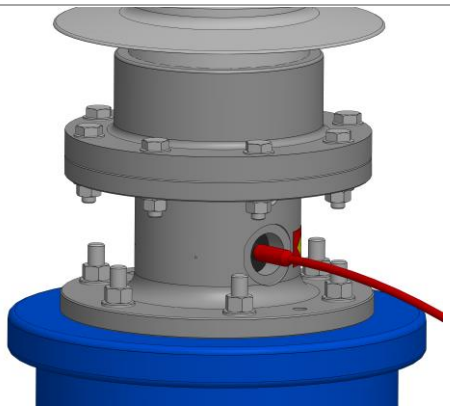
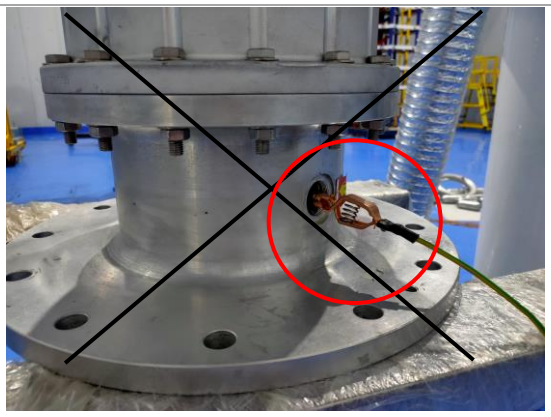
	Before charging bushing, the test tap cap must be closed tightly with O-ring. Ensure O-ring of test tap cover is adequately compressed to avoid moisture ingress. If test tap cap is not closed effectively, this will result in the last layer of condenser core not connected to earth or will be floating and high voltages will appear across test tap and mounting flange and 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. **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 head electrode and air end terminal sealing of the bushing.
4. Repeated Air release after waiting time of 24 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.

	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 Oring is must to avoid ingress of moisture on test tap insulation.

	 Figure 36: Banana socket	 Figure 37: Don't use Crocodile clip
	Use a banana socket to connect multicontact pin ø4mm diameter (Measurement cable is not part of supply)	Do not use the crocodile clip to avoid damage to the multicontact provided on test tap stem

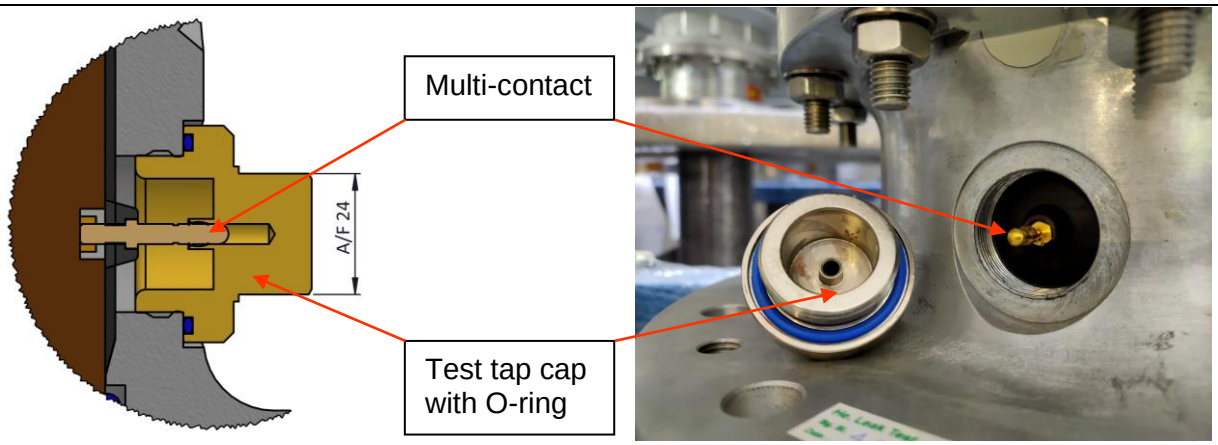


Figure 38 : Test tap detail

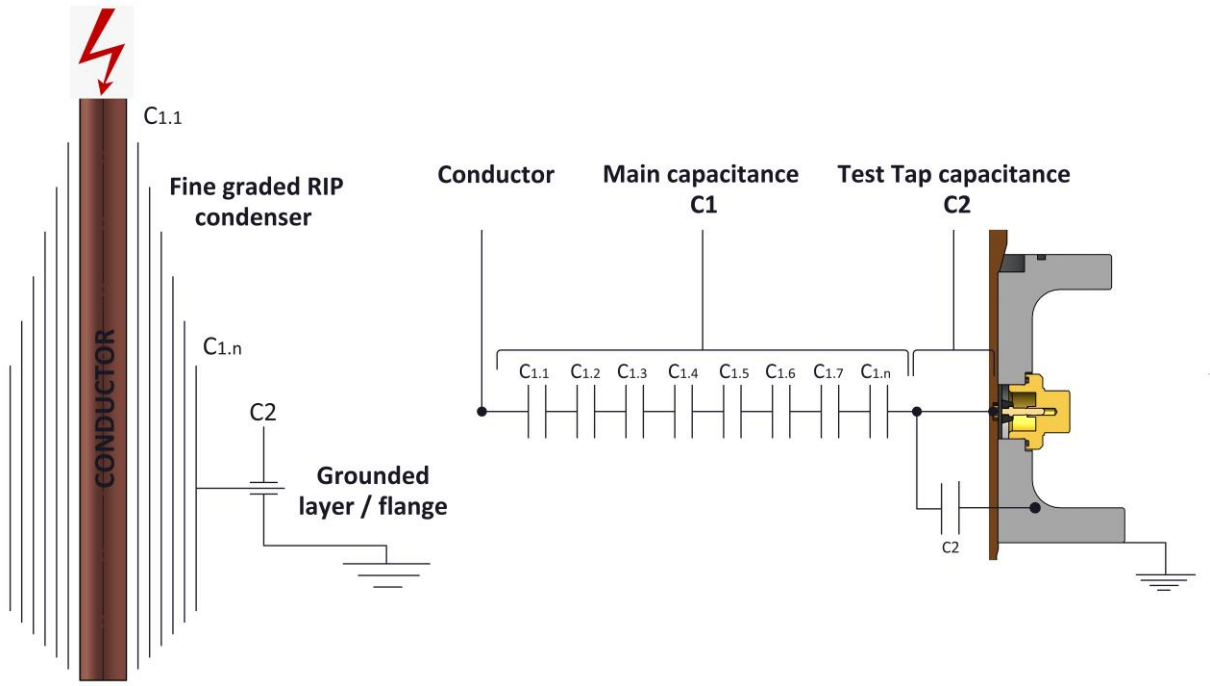


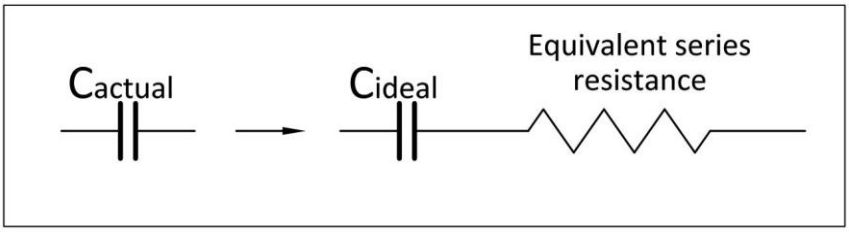
Figure 39: Principle of functioning - Capacitance and Tan Delta Configuration

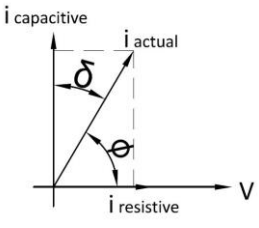
5.1 Capacitance measurement C1 and C2

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 Dielectric dissipation factor / tan δ1 (Main Insulation – C1) and tan δ2 (Test Tap to Earth-C2) measurement

The ideal bushing insulation is a pure capacitance, but the real bushing insulation is an ideal 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:



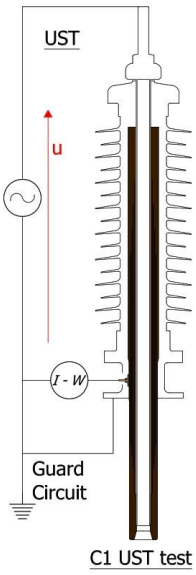


5.3 Parameters that affect the Capacitance and tan δ

5.3.1 CONNECTION OF BUSHING UNDER TEST:

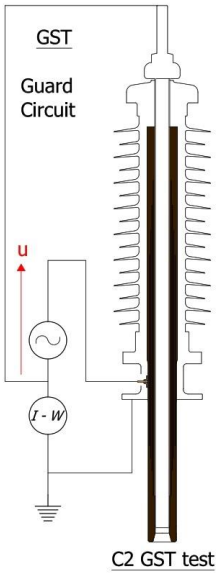
If the Bushing is being tested, in as mounted and connected condition on **transformer**,

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.



C1 UST test

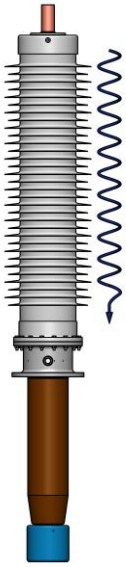
HV terminal → HV point of test kit
Test tap stem → Measurement cable of test kit
Mounting flange → HV guard circuit/ground of test kit

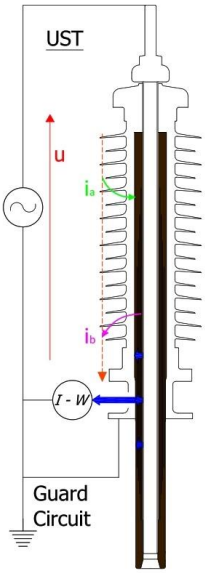


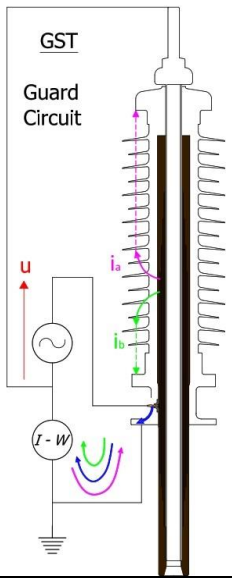
C2 GST test

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:



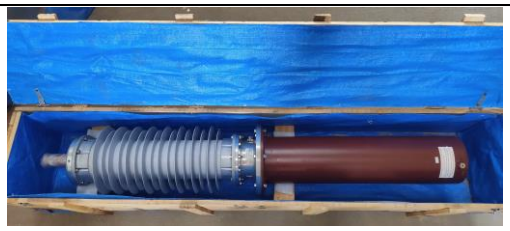




Weather condition: Tan delta shall be measured in dry and sunny weather.
External surface of Bushings (Air end insulator, Oil end Insulator and test tap) must be cleaned thoroughly to remove any foreign particles, conducting particles, dust, humidity, air pressure (altitude) etc, which may give rise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

Some leakage current i_a flows into the Bushing insulation under measurement and some leakage current i_b 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.

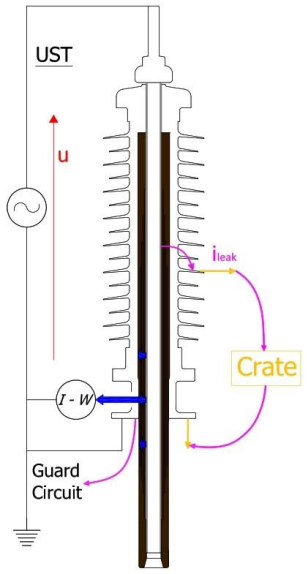
5.3.3. EFFECT OF PARALLEL PATHS FOR RESISTIVE CURRENT:

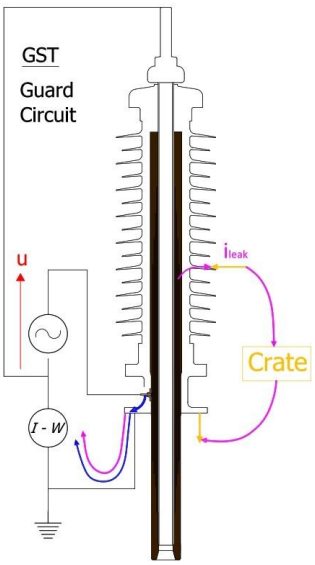


Bushing must be lifted atleast 1 mt. above the ground to nullify the effect of parallel path of ground currents. M**easurement must not be performed inside the wooden box.**

Protection tank must be removed before measurement of tan delta to avoid influence of parallel path of ground current and capacitive coupling.

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





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.

5.4 Relevance of tan δ2 (Test Tap to Earth-C2)

- 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 not recommended to use tan δ2 for bushing diagnostic purposes because this parameter is highly dependent on temperature changes and stray effects of bushing current transformer, turret size etc.

5.5 Temperature correction for Capacitance and Tan delta

Ambient Temperature: Temperature of Insulation influences the permittivity and hence the capacitance and tan δ values, hence during measurement of capacitance and tan δ, ambient temperature shall be as close as possible to that reported in FAT, so that results are comparable

With increasing temperature:

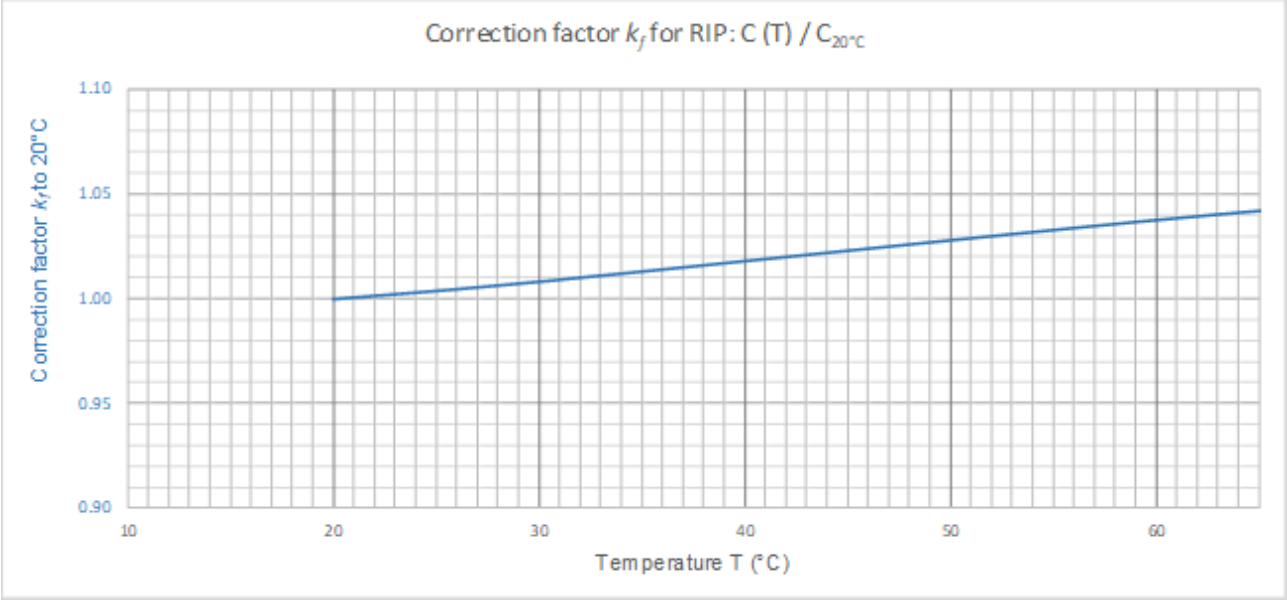
Tan delta 1 decreases (in temperature range 20…60°C)

Capacitance 1 increases

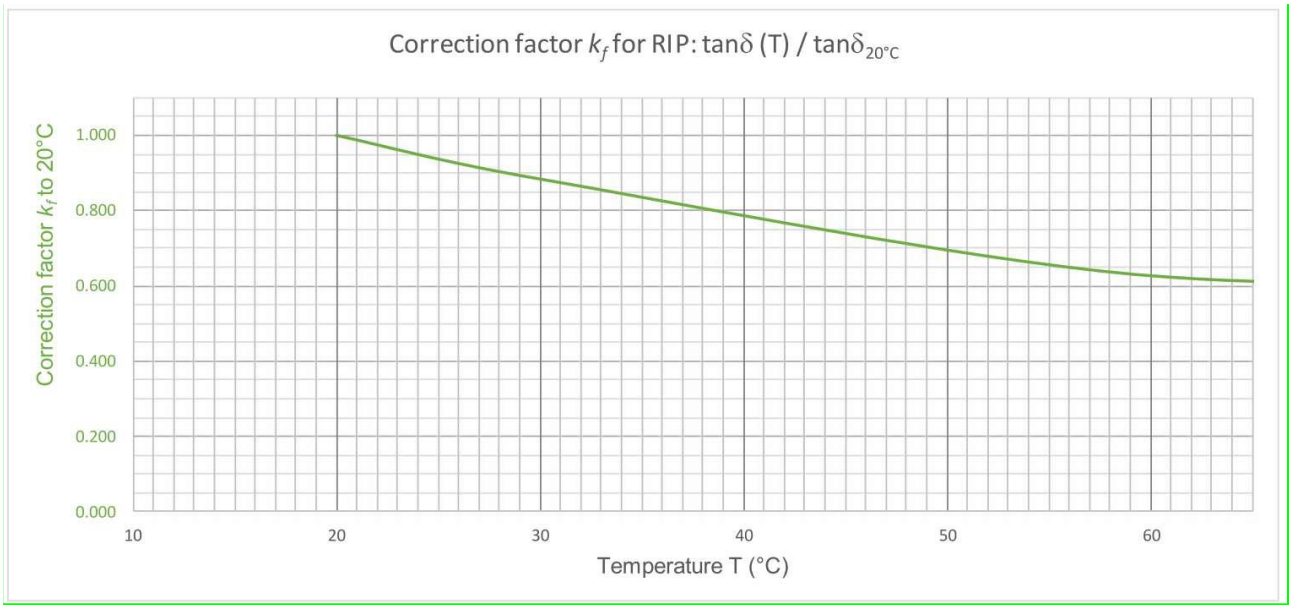
Tan delta 2 increases

Values can therefore deviate from FAT values.

Correction factor for RIP Bushing's Main Capacitance (C1)



Correction factor for RIP Bushing's tan δ1 **of Main capacitance**



Correction of Capacitance and Tan delta for comparison with factory test results, considering 20Deg C as base value for correction.

By example:

For RIP Bushings, if the tan Delta and capacitance are measured at 38 Deg. C during FAT, to obtain the corrected test results at 20 deg C,
For tan delta → divide tan delta value by correction factor of 0.8 to arrive at tan Delta values at 20 Deg. C
For capacitance → divide capacitance tan delta value by correction factor of 1.015 to arrive at tan Delta values at 20 Deg. C
Similarly, for the same bushing, if the tan Delta and capacitance are measured at 30 Deg. C at site, to obtain the corrected test results at 20 deg C,
For tan delta → divide tan delta value by correction factor of 0.875 to arrive at tan Delta values at 20 Deg. C
For capacitance → divide capacitance tan delta value by correction factor of 1.01 to arrive at tan Delta values at 20 Deg. C
In case of doubt contact YASH for assistance.

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.

	**Hint** Use temperature correction factor for both capacitance and tan delta to compare with the base value.

Capacitance C_1	should not change more than 2% under the same test conditions
tan δ1	usually, bushings have tan delta in the range of 0.3 to 0.5% at 40 deg C. Tan delta should not exceed 0.7 % within the ambient temperature range of 20 deg C. to 40 deg C.
Capacitance C_2	should be less than 10,000 pF
tan δ2	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.

5.6 Thermography at air end connections

At maximum rated current, the bushing temperature is about 45 to 55 °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 have to be examined more closely. If necessary, contact YASH.

6. REPACKING

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 i.e Protection tank, Plastic bag packing.

	**Attention** Bushing must be repacked with a Protection tank on oil side to protect bushing from Moisture and should be stored indoor in clean and dry environment.

	**Attention** After fixing the tank, The Oil filling plug of Protection tank must be straight upwards and Oil drain plug and Oil level plug should align to vertical straight line.

	**Caution** Oil filling in protection tank must be done in clean and dry environment to avoid moisture/foreign particles ingress.

	**Caution** During Oil filling in protection tank, ensure Bushing is in straight horizontal condition.

	**Hint:** Fix the Protection tank vertically on Oil side of Bushing in the reverse steps in which it was removed. Oil quality inside protection tank must be in good condition and should have; BDV> 70kV, Tan delta< 0.005, Water content < 5PPM.

	**Caution** The bushing wooden supports should be fixed in such a way that bushing does not move axially or sideways.

7. MAINTENANCE

Bushings are practically maintenance free. Though, following checks are recommended every 6 months:

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

1) Capacitance and tan δ

It is recommended to perform Capacitance and tan delta measurement at interval of six months for first year and after 1 year measurements shall be done atleast once every year. (See section 6).

	**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 delta1 is above 0.7% or if the capacitance Change is more than 2% under the same test conditions

2) Cleaning the silicone sheds

The hydrophobic properties of silicone rubber cause significantly less leakage currents, resulting in an excellent performance in polluted environments. Silicone rubber prevents the formation of conductive paths which lead to flashovers, line outages or erosions on the insulator. Therefore, there is no need for an additional coat.

	**Attention** Contact of Transformer oil with silicone rubber must be avoided as it may result into Silicon rubber shed's Permanent and irrecoverable deformation and change in properties.

	**Attention** Rodent bitten sheds must not be used. YASH must be contacted for further analysis and action in such cases.

	**Hint** In case of exceptional severe site conditions, the insulator can be cleaned manually with soap/water and soft cloth. No oils or detergents should be used. Silicone rubber retains its hydrophobicity after washing. In case of contamination of silicone by transformer oil: We recommend using Acetone, Isopropyl alcohol or White spirit. This solvent should be used together with a clean cloth to remove the transformer oil from the surface of the insulator, immediately after exposure of silicon sheds to transformer oil. Contact YASH for more assistance.

8. DISPOSAL OF BUSHING AFTER SERVICE LIFE

After unpacking of bushing at site, packing box & metal to be recycled to avoid soil & water pollution.

The bushings are made with following components:

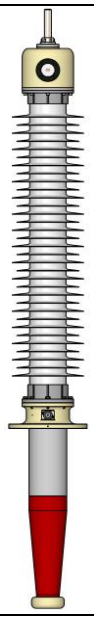
- Central tube or conductor is made of either aluminium or copper
- Active part is composed of resin impregnated paper with aluminium foils.
- Flange, Electrode and Bushing head are made of aluminium
- Hollow composite Insulator is composed of silicone rubber, fibre-glass epoxy, aluminium
- Filling material made of polyurethane elastomer
- Thimble, split conductor are made of copper
- Screws, bolts, pins, washer, protection tank are made of steel

As most of these parts are fixed together, we recommend to cut the bushing in several parts.

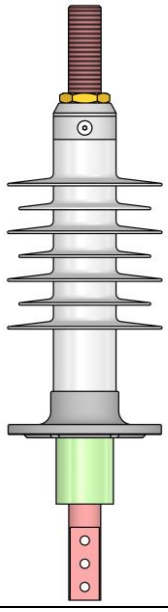
None of the bushings contains any liquids and components can be recycled or disposed as per local regulations of the region.

9. NOTES

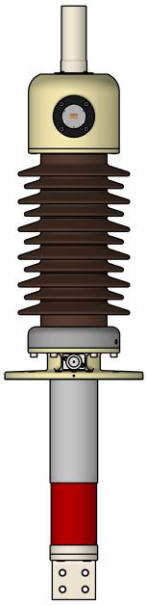
DISTINGUISHED PRODUCT RANGE

OIP bushings with Porcelain/Polymer housing upto 245 kV

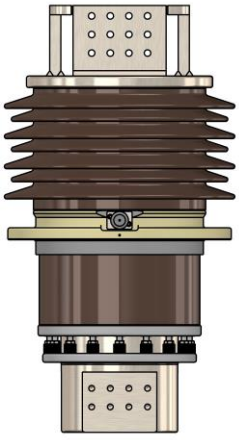


LV Oil Insulated Polymer Bushings upto 36kV 3150 Amp

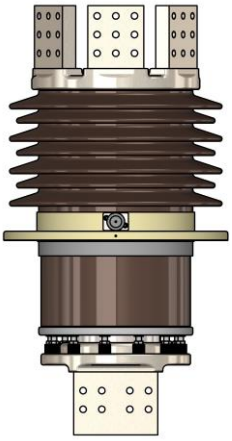


LV OIP bushings Upto 4000 Amp

Retrofit/Replacement of reputed make bushings



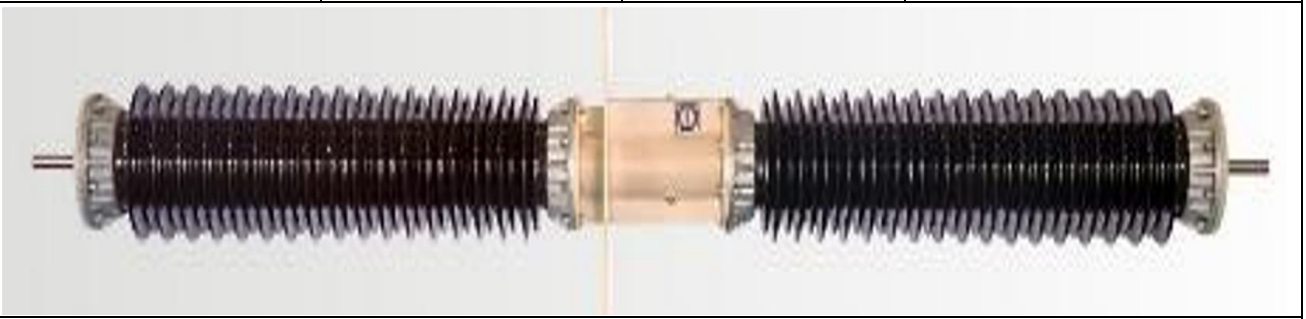
Oil filled High-current bushings Upto 16000 Amps



OIP High-current bushings Upto 20000 Amps

Retrofit High-current bushings

Oil TO Oil OIP bushings Upto 245 kV



OIP and RIP wall bushings upto 245 kV

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