Transformer bushings, type GSA-OO
Installation and maintenance guide
The information provided in this document is intended to be general and does not cover all possible applications. Any specific application not covered should be referred directly to ABB, or its authorized representative.

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Safety information

Keep this instruction available to those responsible for the installation, maintenance, and operation of the bushing.

The installation, operation, and maintenance of a bushing present numerous potential unsafe conditions, including, but not limited to, the following:

- High pressures
- Lethal voltages
- Moving machinery
- Heavy components
- Slip, stumble or fall

Specialized procedures and instructions are required and must be adhered to when working on such apparatus. Failure to follow the instructions could result in severe personal injury, death, and/or product or property damage.

Additionally, all applicable safety procedures such as regional or local safety rules and regulations, safe working practices, and good judgement must be used by the personnel when installing, operating, maintaining and/or disposing such equipment.

Safety, as defined in this instruction, involves two conditions:

1. Personal injury or death.
2. Product or property damage (includes damage to the bushing or other property, and reduced bushing life).

Safety notations are intended to alert personnel of possible personal injury, death or property damage. They have been inserted in the instructional text prior to the step in which the condition is cited.

The following warnings and notes are used in the manual:

⚠️ WARNING

WARNING indicates an imminently hazardous situation, which if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

WARNING also indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠️ CAUTION

CAUTION indicates a potentially hazardous situation, which if not avoided, may result in minor or moderate injury. It may also be used to alert of unsafe practices.

CAUTION may also indicate property-damage-only hazards.

ℹ️ INFO

INFO provides additional information to assist in carrying out the work described and to provide trouble-free operation.
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1. Description

1.1 Design
Bushings type GSA-OO are intended for immersed-immersed oil-oil service. The design is shown in Fig. 1. For a more detailed description, see Technical Guide, 1ZSE 2750-116. The bushing is of dry type, with Resin Impregnated Paper (RIP) as main insulation and mechanical structure. This gives the advantage of any mounting angle.

All GSA bushings are equipped with a test tap connected to the outer layer of the condenser body. The maximum test voltage for this test tap is 2 kV, one minute at 50 to 60 Hz. It serves as a test tap, and in connection with an external capacitance it can be used as a voltage tap. The operation voltage is limited to 600 V.

The bushing can be connected to the transformer by pull-through conductors of either flexible or solid rod type.

1.2 Operating conditions
The table below shows the standard technical specifications for the GSA oil - oil bushings. For conditions exceeding the below values, please contact ABB.

**Common specifications:**

<table>
<thead>
<tr>
<th>Application:</th>
<th>Transformers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification:</td>
<td>Resin impregnated paper, capacitance graded, completely immersed bushing</td>
</tr>
<tr>
<td>Ambient temperature:</td>
<td>Max. daily mean oil temperature 90 °C. Max. normal load 100 °C, emergency duty 115 °C acc. to IEC 60137</td>
</tr>
<tr>
<td>Type of immersion medium:</td>
<td>Transformer oil or poly-buthylene</td>
</tr>
<tr>
<td>Oil level below bushing flange:</td>
<td>25 mm without flange extension</td>
</tr>
<tr>
<td>Max. pressure of medium:</td>
<td>100 kPa overpressure</td>
</tr>
<tr>
<td>Markings:</td>
<td>Conforming to IEC/IEEE</td>
</tr>
</tbody>
</table>

1.3 Mechanical loading
The bushings are designed for the following cantilever loads applied to the midpoint of the top end terminal or to the bottom end of the solid rod, perpendicularly to the bushing axis. The bushing mounting angle can be anywhere from horizontal to vertical. The values are valid for all different lengths on the oil side.

**Table 1. Mechanical loading.**

<table>
<thead>
<tr>
<th>Bushing</th>
<th>Type test load 1 minute (N)</th>
<th>Max. service load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSA 73-OO/2500</td>
<td>3150</td>
<td>1575</td>
</tr>
<tr>
<td>GSA 123-OO/1600</td>
<td>3150</td>
<td>1575</td>
</tr>
<tr>
<td>GSA 145-OO/1600</td>
<td>4000</td>
<td>2000</td>
</tr>
<tr>
<td>GSA 170-OO/1600</td>
<td>4000</td>
<td>2000</td>
</tr>
<tr>
<td>GSA 245-OO/1250</td>
<td>4000</td>
<td>2000</td>
</tr>
</tbody>
</table>

1.4 Spare parts
In case of major damage to the bushing we recommend that it is sent back to ABB for possible repair and re-testing. Certain parts (Figs. 4 and 5), which may be damaged or lost during transport or installation, can be ordered from ABB.
2. Installation

2.1 Tools
- Hook spanner 110/115 mm, 6896 743-2 (supplied in each transport box)
- Lifting eye screw M 12 (DIN 580) for mounting at an angle, 2183 2001-3
- Pull-through cord with M8 swivel, 9760 669-A
- Key for hexagon head 30 mm or adjustable wrench for 30 mm or bigger (For test tap cover)

2.2 Consumables
- Water free vaseline, Mobilgrease 28 or other suitable lubricant not harmful to the transformer oil, to lubricate screws that come into contact with the transformer oil.
- Mobilgrease 28 or other suitable grease to lubricate and protect the earthing screw and the outer terminal o-ring gasket.

2.3 Transport, storage and handling
The bushing shall be surrounded by a sealed moisture-proof wrapping material together with a drying agent during storage and transportation.

Keep the bushing protected from penetrating water when stored outdoors. This means that the case must not be stored in areas where it can be foreseen that the ground will be wet and muddy during heavy rains. Shelter the case from rain and snow with a tarpaulin or roofing.

The bushings are normally delivered from ABB in boxes with the bushing supported by blocks and fibre boards. The boxes are marked with "Top End". The supplied protective wrapping shall not be opened if the bushings are intended to be stored. After transformer test, it is also important to reseal the bushing with the supplied protective wrapping or a similar moisture-proof wrapping, together with a drying agent. The wrapping works as protection for transportation and storage (< 6 months). For longer storage time, contact ABB.

The bushing may be transported and stored in any angle. Carefully inspect the bushing on receiving with regard to shipping damage. Please note that the bushing has been routine tested in oil and some oil may be left, especially in the narrow opening between condenser body and flange.

2.4 Lifting from the box

CAUTION

For lifting the bushing from the box, apply two clean lifting slings as shown in the figure below. Support the bushing at the same points as in the box if placed on the ground. Light bushings may be handled manually.

---

Fig. 2. Lifting from the box.
2.5 Mounting

**CAUTION**

Light bushings may be handled manually. Lift heavier bushings with the aid of one or two lifting eye screws M12. Lift the bushing to vertical position and to an angle according to the figures below. Use a soft bedding under the bottom end of the bushing, e.g. a rubber mat.

The mass of the bushing is stated on the marking plate. Carefully clean and inspect the bushing and the inside of the centre hole before mounting on the transformer.

---

Fig. 3. Mounting.
2.5.1 Outer/inner terminal / Stranded cable

Mounting of the conductor must be performed according to the procedure below. The contact surfaces must be clean.

1. Stretch the stranded cable with the brazed outer/inner terminal, normally fastened to the cover plate. Avoid making any loops.
2. Lubricate the O-ring with Mobilgrease 28 and place the O-ring at the top of the bushing. Drop the pull-through cord through the bushing centre hole, through the O-ring.
3. Lift the bushing above the opening.
4. Fasten the M8 swivel to the outer/inner terminal at the end of the stranded cable. Lower the bushing into the transformer while directing the stranded cable by keeping the pull-through cord taut.
5. Fix the bushing to the cover. Torque M12 to 50 ±5 Nm, 1/2" UNC to 55 ±5 Nm. Ensure to tighten the bolts evenly crosswise in order to avoid damages to the flange.
6. Place the divided ring around the slot in the outer/inner terminal according to Fig. 4, and push the terminal downwards with the O-ring in its groove until the divided ring rests on the upper surface of the top cap.
7. The divided spring washer (2) shall also be placed in the inner terminal slot above the divided ring.
8. Gently release the pull-through cord with the conductor supported by the divided ring.
9. Remove the pull-through cord.
10. Screw on the supplied top nut and check the control measure in Fig. 4. Tighten the nut properly with the aid of the supplied hook spanner 6896 743-2.

Hammering on the hook spanner, or using extraordinary long tubes on the hook spanner to increase torque, may damage the bushing.

It is important that the stranded cable is positioned in the centre of the lower part of the condenser body. There is otherwise a certain risk that the electrical field affecting the lower end of the high voltage foil will be too high. The centre position of the stranded cable can be achieved by means of a thicker layer of insulating paper around the lead. Allowed deviation for the stranded cable from the centre of the bushing is ± 5 mm. It is however important to have a loose of a few mm between the paper and the bushing hole, in order to let oil enter the centre hole when filling the transformer.
During assembly of the top nut, the terminal can be held in position using a torque wrench. The sealing properties of the terminal will not be affected if the terminal is twisted.

There can be a certain loose between the top nut and the terminal after assembly. This is completely normal and does not affect neither the sealing system nor any other properties of the bushing terminal. To protect the painted surface of the nut, a soft bedding, e.g. a piece of cloth or rubber mat, shall be placed between the tool and the nut, see Fig. 5.

### 2.5.2 Outer terminal / Solid rod conductor

- Mounting of the conductor must be performed according to the procedure below. The contact surfaces must be clean.

1. Assemble the lower part of the solid rod into the transformer.
2. Attach the upper part of the solid rod to the lower part.
3. Lubricate the 3 x M10 screws with water-free vaseline or Mobilgrease 28 or other suitable lubricant, not harmful to the transformer oil. Insert and tighten to 35-40 Nm.
4. Lift the bushing above the opening.
5. Lubricate the O-ring with Mobilgrease 28 and place the O-ring at the top of the bushing. Drop the pull-through cord through the bushing centre hole, through the O-ring.
6. Fasten the M8 swivel to the top part of the solid conductor.
7. Lower the bushing into the transformer while guiding the solid rod up through the centre hole of the bushing. Keep the pull-through cord taut.
8. Fix the bushing to the cover. Torque M12 to 50 ±5 Nm, 1/2” UNC to 55 ±5 Nm. Ensure to tighten the bolts evenly crosswise in order to avoid damages to the flange.
9. Place the divided ring around the slot in the solid rod and push the rod downwards with the O-ring in its groove until the divided ring rests on the upper surface of the top cap.
10. The divided spring washer shall also be placed in the inner terminal slot above the divided ring.
11. Gently release the pull-through cord with the conductor supported by the divided ring.
12. Screw on the supplied top nut and check the control measure in Fig. 4. Tighten the nut properly with the aid of the supplied hook spanner 6896 743-2.

Hammering on the hook spanner, or using extraordinary long tubes on the hook spanner to increase torque, may damage the bushing.

During assembly of the top nut, the terminal can be held in position using a torque wrench. The sealing properties of the terminal will not be affected if the terminal is twisted.

There can be a certain loose between the top nut and the terminal after assembly. This is completely normal and does not affect neither the sealing system nor any other properties of the bushing terminal. To protect the painted surface of the nut, a soft bedding, e.g. a piece of cloth or rubber mat, shall be placed between the tool and the nut, see Fig. 5.
2.5.3 Mounting of top end shield on GSA 73-, 123-, 145- and 170-OO

1. Place the fastening plate by letting the outer terminal be inserted in the centre hole and lower it until it rests on the edge.
2. Tighten the socket screw with a torque wrench to approximately 8-10 Nm.
3. Mount the shield on the fastening plate with the washer and the socket screws.

Fig. 7. Top end shield, LF 170 020-S
1. Shield
2. Fastening plate
3. Socket screw M6x40, 2121 2519-378
4. Washer, 2151 2064-153
5. Socket screw M6x16, 2121 2519-368
2.5.4 Mounting of top end shield on GSA 245-OO

1. Place the fastening plate on the outer terminal (standard for 245 kV) and lower it until it rests on the edge.
2. Tighten the socket screw with a torque wrench to approximately 8-10 Nm.
3. Mount the guiding sleeves, the springs, the pressing ring and the socket screw on the fastening plate. The function of the guiding sleeves is to permit the pressing ring and the spring to move along the socket screws.
4. Insert the busbar connection through the shield and connect the busbar to the bushing terminal.
5. Push the shield to the fastening plate.
6. Press the springs together.
7. Guide the socket screws through the key holes in the shield.
8. Turn the shield back somewhat to check that the heads of the screws are in the locking position, see Fig. 8.
9. Turn the shield to stop (approx. 20°). Let the springs press the shield down.

Fig. 8. Mounting of top end shield (LF 170 046-AT) for 245 kV.
1. Fastening plate
2. Spring, 2129 2011-488
3. Guiding sleeve, 12/10 x 17
4. Pressing ring
5. Socket screw M10 x 25
6. Shield
7. Bushing terminal
2.6 Flange earthing
The bushing flange is provided with two tapped holes M12. After tightening the bolts fixing the bushing to the transformer tank, the flange should be earthed. This prevents electrical discharges between bushing flange and transformer tank under normal service conditions.

Alternative 1
Insert a heavily greased (Mobilgrease 28 recommended) pointed set screw M12 (stainless steel A4-80 preferably) in one of the threaded holes. Tighten to 40 Nm, penetrating the paint of the transformer tank down to the metal underneath. This makes an electrical connection between the bushing and the transformer tank, keeping them at the same voltage.

Alternative 2
Apply a flexible cable between the M12 earthing hole in the bushing flange and a corresponding connection point in the transformer. Grease the screw (Mobilgrease 28 recommended) and tighten the M12 in the bushing to 40 Nm. Connect the other end of the cable to the transformer.

2.7 Waiting time before energizing
Some waiting time may be necessary before energizing, in order to avoid flashovers or partial discharges due to air bubbles at the bushing surface. Choose a suitable procedure below.

Vacuum filled transformer
No waiting time is necessary from the bushing point of view.

De-gassed oil-filled transformer
During mounting, use a clean and dry paintbrush to release surface bubbles. Wait 6 hours before energizing.

Gas-saturated oil-filled transformer
During mounting, use a clean and dry paintbrush to release surface bubbles. Wait 24 hours before energizing.

De-gassed oil filled transformer with reduced oil-level
After restoring the oil-level, wait 24 hours before energizing.

For all alternatives except vacuum-filled transformer, the oil should be allowed to enter the centre tube to at least flange height by releasing the outer terminal sealing system and allowing air to escape this way.

2.8 Recommended tests before energizing
The following tests may be performed to check the insulation, sealing and current path of the bushing. The tests should be made after mounting, but before connecting the outer terminal of the bushing to the rest of the switchyard power circuit.

1. Tightness test between transformer and bushing flange.
2. Tightness test of bushing outer terminal.
3. Measurement of capacitance and tan \( \delta \).
4. Check of through-resistance.

2.8.1 Tightness test between transformer and bushing flange
Several different methods may be used and we thus refer to instructions given by the company responsible for the field erection. As a simple example, the tightness of the seal between transformer and bushing flange may be checked when the transformer is oil-filled by using chalk or, perhaps easier, with paper strips.

1. Put a tracer gas into the centre tube before mounting the outer terminal. The oil level of the transformer must be above the bottom end of the bushing but below the bushing flange.
2. Increase the pressure in the center tube by increasing the oil level as much as possible.
3. Search with a gas detector (sniffer) for leaking gas at the gasket.

2.8.2 Tightness test of bushing outer terminal
It is recommended to make a tightness test after assembly, preferably both with vacuum and over-pressure. Several different methods may be used and we refer to instructions given by the firm responsible for the field erection.

One possible method is the tracer gas method:

1. Put a tracer gas into the centre tube before mounting the outer terminal. The oil level of the transformer must be above the bottom end of the bushing but below the bushing flange.
2. Increase the pressure in the center tube by increasing the oil level as much as possible.
3. Search with a gas detector (sniffer) for leaking gas at the gasket.
2.8.3 Measurement of capacitance and tan δ

CAUTION

Since $C_2$ usually is relatively small, the test tap must never be open-circuited when applying a voltage to the bushing. It shall always be earthed or connected to an external impedance. No connection may destroy the bushing.

When not measuring, always make sure that the cap nut is properly tightened with the gasket in place. This is to prevent dust and water from coming in to the test tap.

After mounting, a capacitance measurement is recommended. Connect a measuring bridge between the outer terminal and the test tap. This is possible without removing the bushing from the transformer as the bushing has an insulated test tap, see Fig. 9. More details can be found in product information 2750 515-142, "Bushing diagnostics and conditioning".

Table 2. Nominal capacitances in pF (Manufacturing tolerances for $C_1 \pm 10\%$).

<table>
<thead>
<tr>
<th>GSA-OO</th>
<th>Space for CT = 0/100</th>
<th>Space for CT = 300</th>
<th>Space for CT = 500/600</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_1</td>
<td>C_2</td>
<td>C_1</td>
<td>C_2</td>
</tr>
<tr>
<td>73</td>
<td>184</td>
<td>426</td>
<td>594</td>
</tr>
<tr>
<td>123</td>
<td>149</td>
<td>273</td>
<td>361</td>
</tr>
<tr>
<td>145</td>
<td>218</td>
<td>302</td>
<td>396</td>
</tr>
<tr>
<td>170</td>
<td>252</td>
<td>333</td>
<td>415</td>
</tr>
<tr>
<td>245</td>
<td>212</td>
<td>278</td>
<td>375</td>
</tr>
</tbody>
</table>

2.8.4 Check of through resistance

The through resistance measurement method depends on the design of the transformer. Generally, a current is applied from bushing to bushing. The voltage drop from outer terminal to outer terminal is measured. The resistance is calculated by using Ohm’s law, $U = R.I.$ ($U$: Measured voltage drop, $I$: Through current, $R$: Total circuit resistance.)

The total through resistance is the sum of the transformer winding and lead resistance and the bushing conductor and contact resistance. The additional resistance from the bushing conductor should not be more than $1 \Omega \ldots 100 \text{ m}\Omega$. Since the through resistance of the HV winding of a typical power transformer is in the order of $0.1 \ldots 1 \Omega$, this is a very rough method that can only be used to detect very large faults in the current path, such as disruptions.

Less-than-perfect contacts can only be detected by making a sensitive measurement across each connection point, or by measuring the temperature increase during operation with an infrared sensitive camera (thermovision).
3. Maintenance

The GSA bushings are in principle maintenance free; no regular maintenance is needed.

**WARNING**

No work at all can be performed on the bushing while it is energized or not earthed.

3.1 Recommended maintenance and supervision
1. Measurement of capacitance and tan δ
2. Check for leakage

3.1.1 Measurement of capacitance and tan δ
Please refer to Chapter 2, Installation.

3.1.2 Check for leakage
Make a visual inspection for oil leakage during normal station supervision.

3.2 Disposal after end of service life

Conductors and outer/inner terminals are separable from the bushing by screw joints. Conductors are of pure copper. Outer/inner terminals are of pure copper. Connectors may be plated with for instance silver, tin, gold or nickel in layer thicknesses up to 20 mm. The top nut is made of brass.

The bushing flange (cast aluminium AlMgSi1) is fixed with glue and must be broken away by force in the direction downwards towards the transformer end, preferably at a temperature of 150 °C where the glue starts losing some of its shearing strength. The top cap (wrought aluminium AlMgSi1) is very strongly attached to the condenser body and must be cut or broken off, broken preferably at an elevated temperature, 150 °C.

The epoxy resin impregnated paper condenser body contains approximately 1% (by weight) aluminium foils. It contains approx. 2 g of silver in glue joints, and 1 g of lead in the soldered joint of the measuring tap cable. The epoxy and paper material of the condenser body can be incinerated in an oven suitable for curable plastics and the mentioned metals, or deposited.

Screws and washers are made of stainless steel.

The supplied protective wrapping contains polyethylene, polyester and approx. 11 % (by weight) aluminium. The supplied wrapping can be incinerated in a suitable oven.
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