Transformer bushing, type GSB
Installation and maintenance guide
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1 Safety

1.1 Levels of safety risks

Throughout the manual, various types of safety risks are indicated. The most serious level on this scale provides a warning about serious personal injury or possible death, or major damage to a product, if the instructions are not observed.

Symbols and their meanings.

The following describes the symbols that appear in the manual, along with their meaning.

**DANGER!**
The yellow, filled warning triangle warns that an accident will occur if the instructions are not complied with and that it will result in serious personal injury or death and/or major damage to the product.

It is used, for example, to warn of such dangers as: contact with high voltage, explosion or fire risk, risk for toxic gases, risk of crushing, impacts, falls from high places, etc.

**CAUTION!**
The round warning symbol warns that an accident could occur if the instructions are not observed, and that this could result in personal injury and/or damage to the product.

It is also used to warn of risks that entail burns, eye or skin injuries, impaired hearing, crushing or slipping injuries, tripping, impacts, falls from high places, etc.

In addition, it is used to warn about functional requirements when assembling or removing equipment where there is a risk of damage to the product or that it might cause downtime.

**NOTE!**
The comment symbol identifies important information and conditions. Also used to indicate any danger that could lead to property damage.

**Torque**
The torque symbol indicates the tightening torque.

1.2 Hazardous working situations

For all work on high-voltage devices, the following risks must be observed and corresponding measures taken.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working close to high voltage</td>
<td>Disconnect and earth around the workplace. If work must be carried out close to live plant components, the safety distance must be in compliance with the applicable safety regulations.</td>
</tr>
<tr>
<td>Working on ladders and platforms</td>
<td>Work must be executed in accordance with applicable safety regulations. Avoid the use of ladders and platforms in poor weather conditions.</td>
</tr>
</tbody>
</table>
2 Product description

2.1 Design

GSB is a resin impregnated paper (RIP) bushing intended for immersed oil-air service. The bushing is of the dry type, with resin impregnated paper (RIP) as the primary insulation and silicone rubber (SiR) weather sheds on outdoor surfaces. This provides the benefits of being able to mount the bushing at any angle from vertical to horizontal.

The bushing is built around an aluminum center tube on which the condenser core is wound. This core is wound with crepe paper with aluminum foil inserts for electrical stress control and impregnated and cured under vacuum, producing a partial discharge free bushing with low tan δ (dissipation factor). After curing, the body is machined and a flange and an insulator are fitted. The insulator is made of composite materials. The space between the RIP body and the insulator is then filled with an insulating gel. As the current conductor, the GSB uses the center tube, which is molded into the RIP core. The oil side connection can be made with a draw-rod system with a bottom contact, an inner terminal for draw lead or a fixed bottom contact. The bottom contact is normally delivered with an end shield. An alternative bottom contact is available if a different end-shield is intended to be used. For the air side connection there are studs available in a number of standard configurations, but modifications can be made to suit any connection requirement.

For a more detailed description, see the Technical Guide, 1ZSC000563-AAC.

Test tap

All bushings are equipped with a test tap connected to the outer layer of the condenser body. The test tap can be used for measuring the bushing insulation by capacitance and dissipation factor. During operation the protective cap must be fitted to ground the outer layer to the flange. 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 operating voltage is limited to 600 V.

Voltage tap $U_{RI} = 6$ kV is available as an option.
1  Outer terminal
2  Composite insulator with silicon sheds
3  Mounting flange
4  RIP condenser core
5  Shield
6  Test tap / Voltage tap
2.2 Technical specifications

2.2.1 General specifications

The table shows the standard technical specifications for the GSB oil - air bushings. For conditions exceeding the values, please contact ABB.

<table>
<thead>
<tr>
<th>Application:</th>
<th>Transformers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification:</td>
<td>Resin impregnated paper, capacitance graded, outdoor immersed bushing, temperature class E (120 °C) according to IEC 60137.</td>
</tr>
<tr>
<td>Ambient temperature:</td>
<td>+40 °C to -40 °C, minimum value according to temperature class 3 of IEC 60137. (60 °C according to GOST 10693-81 in applicable parts.)</td>
</tr>
<tr>
<td>Altitude of site:</td>
<td>&lt; 1000 m</td>
</tr>
<tr>
<td>Level of rain and humidity:</td>
<td>1-2 mm rain/min. horizontally and vertically, as per IEC 60060-1, and 5 mm/min. as per IEEE.</td>
</tr>
<tr>
<td>Pollution level:</td>
<td>According to specific creepage distance and IEC 60815.</td>
</tr>
<tr>
<td>Immersion medium:</td>
<td>Transformer oil. Maximum daily mean oil temperature: 90 °C. Maximum temporary temperature, normal load: 100 °C. Maximum temporary temperature, short time overload: 115 °C.</td>
</tr>
<tr>
<td>Oil level in transformer:</td>
<td>No lower than 25 mm from the bushing flange.</td>
</tr>
<tr>
<td>Angle of mounting:</td>
<td>Horizontal to vertical.</td>
</tr>
<tr>
<td>Test tap:</td>
<td>According to IEEE potential tap type A. (U_r=\max 600\ \text{V})</td>
</tr>
<tr>
<td>Voltage tap:</td>
<td>According to IEEE potential tap type A. (U_r=6\ \text{kV})</td>
</tr>
<tr>
<td>Capacitance C2 of test tap:</td>
<td>&lt; 5000 pF</td>
</tr>
<tr>
<td>Capacitance C2 of voltage tap:</td>
<td>See Measurement of capacitance and tan (d), page 36.</td>
</tr>
<tr>
<td>Arcing horns:</td>
<td>N/A</td>
</tr>
<tr>
<td>Conductor:</td>
<td>Center tube or flexible draw lead conductor.</td>
</tr>
<tr>
<td>Markings:</td>
<td>Conforming to IEC/IEEE.</td>
</tr>
</tbody>
</table>

2.2.2 Mechanical loading

The bushings are designed for the following cantilever loads applied to the midpoint of the top end terminal, 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.

In the axial direction the GSB bushing can continuously withstand 20 kN. The maximum torque on the outer terminal stud is 200 Nm.

<table>
<thead>
<tr>
<th>Bushing</th>
<th>Max. cantilever operating load for vertical mounting (N)</th>
<th>Max. cantilever operating load for horizontal mounting (N)</th>
<th>Max. cantilever test load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSB 245</td>
<td>2800</td>
<td>2000</td>
<td>5600</td>
</tr>
<tr>
<td>GSB 362</td>
<td>3200</td>
<td>2000</td>
<td>6300</td>
</tr>
<tr>
<td>GSB 420</td>
<td>3300</td>
<td>2000</td>
<td>6600</td>
</tr>
<tr>
<td>GSB 550</td>
<td>6500</td>
<td>4000</td>
<td>13000</td>
</tr>
</tbody>
</table>
3 Delivery

3.1 Transport and long term storage

Do not allow the bushings to rest on the silicone rubber sheds during transport or storage, deformation will otherwise occur. Keep the bushings dry and clean and protected against mechanical damage.

A metallic sealing container, containing drying agent, is fitted on the oil side of the bushing. The sealing container will protect the oil side from moisture absorption. It is important that the sealing container is fitted during transport and storage. The container is suitable both for short-time storage (≤6 months) and long-time storage. The bushing can be stored outdoors when the sealing container is fitted. As an option, the moisture barrier “RIPCOAT” can be supplied as extra protection when the container is not mounted.

Carefully inspect the bushings upon receiving with regard to shipping damage. Please note that the bushings have been routine tested in oil and some oil may remain, especially in the narrow opening between the condenser body and flange.

The bushings are normally delivered from ABB in boxes with the bushing supported by blocks and fiberboard. The boxes are marked with “Top End”.

3.2 Lifting the bushing

Light bushings may be handled manually. Lift heavier bushings with the aid of a lifting tool. The weight of the bushing is stated on the rating plate.

Lift the bushing to the vertical position and at an angle according to the figures. Use a soft bedding under the bottom end of the bushing, e.g. a rubber mat.

NOTE!
Transformer bushings should be stored in transport boxes until immediately before assembly.

NOTE!
Remove the transport securing device before lifting.

NOTE!
Please note the position of the lifting sling! For polymeric insulators, the lifting sling should be placed as close as possible to the flange and not on the rubber surface.
Lifting from the box

CAUTION!
For lifting the bushing from the box, secure two clean lifting slings as shown. Support the bushing at the same points as in the box if placed on the ground or block it under the flange and the metal top piece. Light bushings may be handled manually.
Lifting the bushing

CAUTION!
The lifting eye of the lifting gear must be aligned with the lifting eye on the flange to avoid rotation and subsequent loosening of the top nut.

1  Lifting tool
2  Soft bedding, i.e. rubber mat or wood board
3  Lifting eye
4 Installation

4.1 Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Part number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifting gear</td>
<td>9760 667-A</td>
<td>i.e. rubber mat or wood board</td>
</tr>
<tr>
<td>Soft bedding</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Soft slings</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Pull-through cord with M8 swivel</td>
<td>9760 669-A</td>
<td></td>
</tr>
<tr>
<td>Torque wrench key for hex bolts,</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>16 mm (M10) and 13 mm (M8),</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>torque 20 to 40 Nm.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Wrench for hex bolt 30 mm or</td>
<td>-</td>
<td>For test tap cover.</td>
</tr>
<tr>
<td>adjustable wrench for 30 mm bolts or larger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shackles</td>
<td>-</td>
<td>For hole Ø 25 mm, for connection of soft slings to the bushing flange</td>
</tr>
<tr>
<td>Box wrench</td>
<td>9760 669-B</td>
<td>For assembly of draw rod</td>
</tr>
<tr>
<td>Tackle</td>
<td>-</td>
<td>For mounting the bushing at a specific angle</td>
</tr>
</tbody>
</table>

4.2 Consumables

<table>
<thead>
<tr>
<th>Brand</th>
<th>Type / Name</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Oil based vaseline</td>
<td>Not harmful to the transformer oil, to lubricate bolts that come into contact with the transformer oil.</td>
</tr>
<tr>
<td>MOBIL</td>
<td>Mobil grease 28</td>
<td>For bolts that come in contact with the transformer oil. Not harmful to the transformer oil, to lubricate and protect the ground bolt and the outer terminal O-ring gasket.</td>
</tr>
<tr>
<td>Dow Corning</td>
<td>Molykote 1000</td>
<td>For lubricating the contact and sealing at the outer terminal.</td>
</tr>
</tbody>
</table>
4.3 Installation using draw rod at the transformer factory

Procedure

**NOTE!**
The draw rod is normally delivered pre-installed in the bushing. The first step at the transformer factory is therefore to remove it.

1. Remove the outer terminal and then the M16 nut (10) at the top of the draw rod.
2. Pull out the draw rod from the bushing tube bottom end and disassemble it.

**NOTE!**
Upper thread is locked (7) with locking liquid 1269 0014-408 (Loctite 270)

3. Attach the winding cables to the bottom contact through the end shield.

**Torque**
68 ± 6 Nm

4. Push the shield gently against the bottom contact. Apply force until the top position is reached.

5. Turn the shield clockwise, approximately 20 degrees, and then release the force. Make sure that the end shield is in the locked position.

6. Carefully clean and inspect the oil end of the bushing and the inside of the center hole.

7. Lift the bushing above the opening on the transformer.
8. Connect the upper draw rod to the pull-through cord (10) and lower it through the compensating device (2).

9. Connect the draw rod (4) to the bottom contact (5).

10. Lower the bushing into the transformer while keeping the pull-through cord (10) taut.

11. Fastening the bushing to the transformer flange.

**Torque**

- M12 50 ±5 Nm
- 1/2" UNC 55 ±5 Nm

**CAUTION!**

If fixed stud bolts are used for fastening the bushing flange, it is advisable to apply plastic sleeves on two or three of the studs both to guide the flange and to prevent chipping of the stud bolts, with the subsequent risk of chips, falling into the transformer.
12. Fit a washer and nut on the draw rod.

13. Remove the lifting gear and the pull-through cord.

14. Each bushing with a draw rod is supplied with an information sheet specifying the measurement (b-a), measured at the factory, and torque.

   **NOTE!**
   If a bushing is non-standard, the values shall be according to the information stated at each step.

15. Tighten the nut to 10 Nm and measure the distance (a) from the top of the nut to the top of the bolt.

16. Continue tightening the nut until the difference between the first (a) and second measurement (b) matches the relevant value:

   - GSB 245  7.0 mm
   - GSB 362  8.5 mm
   - GSB 420  9.5 mm
   - GSB 550  12.0 mm

   Each turn corresponds to an extension of 2 mm
17. Use a torque wrench to ensure that the nut is tightened to a torque of more than 70 Nm but less than 140 Nm.

18. Alternatively; use a jack to tighten the draw rod bolt to a force according to the next value. Tighten the nut by the hand and then release the jack.

| Force with CT extension 300 mm / 600 mm (kN) | GSB 245 | 36.0 / 34.5 |
|                                          | GSB 362 | 37.5 / 36.1 |
|                                          | GSB 420 | 38.1 / 36.5 |
|                                          | GSB 550 | 38.5 / 37.3 |


End of instruction

4.4 Installation using draw rod at site

1. Upper draw rod
2. Compensating device
3. Flexible pull-through cord
4. Lower draw rod
5. Bottom contact
6. Bushing
Procedure

NOTE!
This procedure is only valid if the lower draw rod is already installed in the transformer.

1. Remove the outer terminal and then the M16 nut (10) at the top of the draw rod.

2. Pull out the upper draw rod from the bushing tube.

3. Carefully clean and inspect the oil end of the bushing and the inside of the center hole.

4. Remove the transport cover with the oil side part of the draw rod and bottom contact (5) from the transformer (11).

5. Lift the bushing above the opening on the transformer.

CAUTION!
The bushing and transformer shall have been marked for final erection at the same position.
6. Coat the unlocked lower threads (8) on the draw rod with locking liquid (Loctite 270).

7. Connect the upper draw rod to the pull-through cord (10) and lower it through the compensating device (2).

8. Connect the draw rod (4) to the bottom contact (5).

9. Lower the bushing into the transformer while keeping the pull-through cord (10) taut.
10. Fasten the bushing to the transformer flange.

**Torque**

- M12 50 ±5 Nm
- 1/2” UNC 55 ±5 Nm

**CAUTION!**
If fixed stud bolts are used for fastening the bushing flange, it is advisable to apply plastic sleeves on two or three of the studs both to guide the flange and to prevent chipping of the stud bolts, with the subsequent risk of chips, falling into the transformer.

11. Fit a washer and nut on the draw rod.

12. Remove the lifting gear and the pull-through cord.

13. Each bushing with a draw rod is supplied with an information sheet specifying the measurement (b-a), as measured at the factory, and torque.

**NOTE!**
If a bushing is non-standard, the values shall be according to the information stated at each step.

14. Tighten the nut to 10 Nm and measure the distance (a) from the top of the nut to the top of the bolt.
15. Continue tightening the nut until the difference between the first (a) and second measurement (b) matches the relevant value:

- GSB 245 7.0 mm
- GSB 362 8.5 mm
- GSB 420 9.5 mm
- GSB 550 12.0 mm

Each turn corresponds to an extension of 2 mm.

16. Use a torque wrench to ensure that the nut is tightened to a torque of more than 70 Nm but less than 140 Nm.

17. Alternatively; use a jack to tighten the draw rod bolt to a force according to the next value. Tighten the nut by the hand and then release the jack.

<table>
<thead>
<tr>
<th>Force with CT extension 300 mm / 600 mm (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSB 245</td>
</tr>
<tr>
<td>GSB 362</td>
</tr>
<tr>
<td>GSB 420</td>
</tr>
<tr>
<td>GSB 550</td>
</tr>
</tbody>
</table>


End of instruction
4.5 Installation using stranded cable

Procedure

1. Solder the winding cable/cables from the transformer to the inner terminal (7).

2. Carefully clean and inspect the oil end of the bushing and the inside of the center hole.
3. Drop the pull-through cord (10) through the bushing center hole.

4. Fasten the M8 swivel with the pull-through cord (10) to the inner terminal (7).

5. Push the shield (12) gently against the shield adapter (11). Apply force until the top position is reached.

6. Turn the shield clockwise, approximately 20 degrees, and then release force. Make sure that the end shield is in the locked position.
7. Lower the bushing into the transformer while guiding the stranded cable by keeping the pull-through cord (10) taut.

**NOTE!**
If there are inspection openings near the bushings on the transformer, they must be open while mounting the bushing, in order to ensure that the lead is entering the bushing in the correct manner.

8. Fasten the bushing to the transformer flange.

**Torque**

M12 50 ±5 Nm

1/2” UNC 55 ±5 Nm

**CAUTION!**
If fixed stud bolts are used for fastening the bushing flange, it is advisable to apply plastic sleeves on two or three of the studs both to guide the flange and to prevent chipping of the stud bolts, with the subsequent risk of chips, falling into the transformer.

9. Place the divided ring (6) around the slot in the inner terminal (7).
10. Gently release the pull-through cord (10) so the inner terminal (7) rests on the divided ring (6).

11. Remove the pull-through cord.


End of instruction

### 4.6 Installation using fixed bottom contact

1. Bottom contact
2. Bushing
Procedure

1. Check that there is a distance of 7 ±0.5 mm between the washer on top of the bottom contact and the pull ring.

2. Check the torque of the six bolts.

   Torque
   40 Nm

3. Lift the bushing above the opening on the transformer.

4. Lower and secure the bushing to the transformer.

   Torque
   M12 50 ±5 Nm
   1/2” UNC 55 ±5 Nm

   CAUTION!
   If fixed stud bolts are used for fastening the bushing flange, it is advisable to apply plastic sleeves on two or three of the studs both to guide the flange and to prevent chipping of the stud bolts, with the subsequent risk of chips, falling into the transformer.

5. Remove the lifting gear.

6. Attach the winding cables to the bottom contact through the end shield.

   Torque
   68 ± 6 Nm

7. Push the shield gently against the bottom contact. Apply force until the top position is reached.
8. Turn the shield clockwise, approximately 20 degrees, and then release the force. Make sure that the end shield is in the locked position

End of instruction

4.7 Mounting of outer terminal

1. Carefully clean the contact and gasket surfaces. Lubricate the O-ring (8) with Mobilgrease 28.

   **NOTE!**
   Or use another suitable lubricant, not harmful to the transformer oil.

   **NOTE!**
   The inner contact surfaces on aluminum outer terminals are tin-zinc plated, and subsequently they may not be wire-brushed.

2. Fit the tightening ring (9), the O-ring (8), and the outer terminal stud (5) and push them over the inner terminal/solid rod (7) with the divided ring (6) in place.

3. Grease all bolts, both on threads and beneath the heads with Molykote 1000, or another suitable compound.
4. If used; place top shield on the outer terminal.  

Example of shield:

![Image of shield]

5. Insert and tighten the M10 bolts (2), with flat washers, which press the stud against the inner terminal (or compensating device).

   **Torque**
   Cross tighten to a final torque of 40 ±4 Nm.

   **CAUTION!**
   Do not use an impact driver / wrench!

![Image of M10 bolts]

6. Insert the M8 bolts (1), with conical spring washers and flat washers, that hold the tightening ring.

   Tighten them to press the gasket into place.

   **Torque**
   Cross tighten to a final torque of 20 ±2 Nm.

   **CAUTION!**
   Do not use an impact driver / wrench!

![Image of M8 bolts]

7. **NOTE!**
   Before connection of the conductor clamps, the outer terminals of aluminum must be carefully wire-brushed and greased with a contact compound or vaseline.

---

End of instruction
4.8 Flange grounding

Overview

The bushing flange has a tapped hole M12. After tightening the bolts that secure the bushing to the transformer tank, the flange should be grounded. This prevents electrical discharges between the bushing flange and transformer tank under normal service conditions.

There are two alternatives.

Alternative 1, using pointed set bolt

1. Heavily grease the pointed set bolt (13) with Mobilgrease 28.
   
   **NOTE!**
   Or use another suitable lubricant.

2. Tighten the bolt (13) penetrating the paint of the transformer tank down to the metal beneath. This makes an electrical connection between the bushing and the transformer tank, keeping them at the same voltage.
   
   **Torque**
   40 Nm

End of instruction
Alternative 2, using flexible cable

1. Run a flexible cable (14) between the M12 grounding hole in the bushing flange and a corresponding connection point in the transformer.

2. Heavily grease the bolt (13) with Mobilgrease 28.

   **NOTE!**
   Or use another suitable lubricant.

3. Tighten the bolt (13).

   **Torque**
   40 Nm

4. Connect the other end of the cable (14) to the transformer.

5. This makes an electrical connection between the bushing and the transformer tank, keeping them at the same voltage.

   End of instruction
5 Commissioning

5.1 Waiting time before energizing

Vacuum filled transformer

No waiting time is necessary regarding the bushing.

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 transformers, the oil should be allowed to enter the center tube to at least flange height by releasing the outer terminal sealing system and allowing air to escape.

Oil spillage is not harmful to the silicone rubber insulator. Oil should be removed by wiping with a paper towel to avoid attracting dirt that could reduce insulation performance.

Do not allow oil that has been in contact with silicone rubber to enter the transformer. Such oil may contain small amounts of silicone oil that would reduce the surface tension of the transformer oil subsequently causing foaming during forced oil circulation.

NOTE!
A certain amount of waiting time may be necessary before energizing to avoid flashovers or partial discharges due to air bubbles on the bushing surface. Choose a suitable procedure.
5.2 Recommended tests before energizing

5.2.1 Overview

The following tests should be performed to check the insulation, sealing and current path of the bushing.

NOTE!
The tests should be performed after installation, but before connecting the outer terminal of the bushing to the rest of the switchyard power circuit.

5.2.2 Tightness test between transformer and bushing flange

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

5.2.3 Tightness test of bushing outer terminal

Since the top terminal is often situated above the oil level of the transformer expansion system, a leak at this point is extremely serious, because water could enter directly into the transformer insulation. It is thus recommended to conduct a tightness test after installation, preferably both with a vacuum and over-pressure. Several different methods may be used and we refer to instructions provided by the firm responsible for field erection.

One possible method is the tracer gas method:

1. Put a tracer gas into the center 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 for leaking gas at the gasket with a gas detector (sniffer).

5.2.4 Measurement of capacitance and tan δ

After mounting, a capacitance measurement is recommended. Connect a measuring bridge between the outer terminal and the test tap/voltage tap. Or use ABB’s test tap adapter (2769 522-C). This can be done without removing the bushing as the bushing has an insulated test tap. More details can be found in product information 2750 515-142, “Bushing diagnostics and conditioning”.

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1. Test tap / voltage tap
2. Cover (2769 522-M) with O-ring (1ZSC00442-CAK)
With the transformer de-energized and the bushing outer terminal disconnected, the test tap cover is removed. The measuring equipment is connected to the test tap and the measuring voltage source to the bushing terminal.

The capacitances $C_1$ between the outer terminal and the test tap, and the capacitance $C_2$, between the test tap and the flange are marked on the rating plate. The nominal capacitances $C_1$ of the different bushing types are listed in the table. $C_2$ is highly dependent on the surrounding parts inside the transformer and it is not possible to provide a nominal value valid for all service conditions.

<table>
<thead>
<tr>
<th>Bushing</th>
<th>Space for CT = 300 mm</th>
<th></th>
<th>Space for CT = 600</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$C_1$</td>
<td>$C_2$ (test tap)</td>
<td>$C_2$ (voltage tap)</td>
<td>$C_1$</td>
</tr>
<tr>
<td>GSB 245</td>
<td>663</td>
<td>&lt;5000</td>
<td>6990</td>
<td>769</td>
</tr>
<tr>
<td>GSB 362</td>
<td>619</td>
<td>&lt;5000</td>
<td>9540</td>
<td>701</td>
</tr>
<tr>
<td>GSB 420</td>
<td>579</td>
<td>&lt;5000</td>
<td>10070</td>
<td>662</td>
</tr>
<tr>
<td>GSB 550</td>
<td>553</td>
<td>&lt;5000</td>
<td>13130</td>
<td>612</td>
</tr>
</tbody>
</table>

**NOTE!**
When not measuring, always make sure that the cover is properly tightened with the O-ring in place. This is to prevent dust and water from entering the test tap.

**CAUTION!**
The test tap is not self grounding.

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

### 5.2.5 Check of through resistance

The through resistance measurement method depends on the design of the transformer. In general, a current is applied from bushing to bushing. The voltage drop from outer terminal to outer terminal is measured. The resistance is calculated with Ohm’s law, $U = R \cdot I$. ($U$: 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 150 μΩ. Since the through resistance of the HV winding of a typical power transformer is in the order of 0.1 .. 1 Ω, this is a very rough method that can only be used to detect very large faults in the current path, such as open circuits.

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).
6 Maintenance

6.1 Recommended maintenance

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

**DANGER!**

No work at all may be performed on the bushing while it is energized or ungrounded.

**Cleaning of insulator surface**

Under conditions of extreme pollution it may be necessary to clean the silicone rubber insulator surface. This should be done by wiping with a moist cloth. If necessary, ethyl-alcohol or ethyl-acetate may be used.

**NOTE!**

1,1,1-Trichloroethane or Methylchloride are not recommended due to their possibly harmful and environmentally detrimental properties.

**Measurement of capacitance and tan δ**

Please refer to *Measurement of capacitance and tan δ*, page 36.

**Thermovision (infrared camera) check for local overheating on connectors**

At maximum rated current, the bushing outer terminal normally handles a temperature of about 35 to 45 °C above the ambient air. Significantly higher temperatures, especially at lower current loading, can be a sign of bad connections.

**Tightness check**

Make a visual inspection for oil leakage during normal station supervision.
7 Re-packing

7.1 Re-packing of bushing after testing

NOTE!
The bushing and transformer must be marked for final erection at the same position.

NOTE!
During transport the inner terminal/oil side parts of the draw rod may be fastened to the transport cover in transformer. Upon erection, the transport cover is removed, and the terminal/draw rod loosened.

NOTE!
The metallic sealing tube, with gasket, replaced drying agent and fasteners, should be reassembled after transformer test. Torque 50 Nm.

CAUTION!
For lifting the bushing to the box, apply two clean lifting slings as shown. Support the bushing at the same points as in the box if placed on the ground or block it under the flange and the metal top piece. Light bushings may be handled manually.
NOTE!
Please note the position of the lifting sling! For polymeric insulators, the lifting sling should be placed as close as possible to the flange and not on the rubber surface.

NOTE!
The transformer bushing(s) should be re-packed in the transport box as per delivered. The bushing should be fixed in axial and radial direction, and secured against rotation.

At the ABB factory, the bushing box is closed with bolts and plastic straps. It is advisable to use bolts and plastic straps when reclosing the box after transformer testing.
8 Spare parts

8.1 Summary

In the event of major damage to the bushing we recommend that it be returned to ABB for possible repair and re-testing. Certain parts that may be damaged or lost during transport or installation, can be ordered from ABB.
9 Disposal and environmental information

9.1 Disposal and recycling

ABB strives to minimize the product’s impact on the environment throughout its entire life cycle. Technical and product development focuses on environmental aspects. The ecocycle approach is strived for and consideration is taken to the materials’ environmental impact and recycling alternatives. The manufacturing processes are selected to be as safe for the environment as possible.

Disposing of worn-out equipment

Worn-out equipment must be phased out in an environmentally sound manner.

When disposing of used equipment, much of the material, or energy content in the material, can be recycled following sorting and cleaning. The amount that is recycled varies depending on the technical resources and experience in each country. Non-recyclable components should be sent to an approved environmental waste treatment plant for destruction or disposal.

Gas

The SF₆ gas must be evacuated prior to scrapping of a bushing. All handling of SF₆ gas must be conducted with care and according to the applicable regulations to ensure that there are no gas leaks. The gas can be handled in different ways, depending on the circumstances:

• Regenerated onsite, and reused in other equipment.
• Sent to the gas supplier for regeneration.
• Sent for destruction at a special waste treatment plant.

In cases where the bushing is filled with mixed gas, the SF₆ gas is separated from the mixture for further processing according to the above. Alternatively the gas mixture can be sent for destruction without being separated. Upon request, ABB can provide a quote for final disposal of used gas in connection with the scrapping of a bushing.

Porcelain

After cleaning, the porcelain can be sent for disposal or used for other purposes, such as for use as filling material.

Electronics

Electronics equipment should be sent to an approved recycling company or sorted into different component materials for appropriate treatment.
Metals

Metals should be sorted according to type and surface coating and sent to an approved recycling company. Following the removal of any paint or other surface coating, clean metal can usually be melted down and used in new products. Many metal components of iron, steel and aluminum are large and easy to identify, e.g. support structures. ABB strives to reduce the use of precious metals and the release of environmentally hazardous metals.

Recycling of these is particularly important. Precious metals such as copper and silver are expensive and are only present in small amounts in the Earth’s crust. Copper is primarily used in current paths, puffers, contacts and cables. Silver plating of contacts may occur. Emissions from certain metals may cause damage. This applies to copper, but also zinc and nickel, which are used sparingly as surface coatings.

Plastics

The different types of plastic should be separated and sent to an approved environmental waste treatment plant or recycling company. The energy content in thermoplastics and thermosetting plastics can often be recovered through combustion at a plant designed for the purpose. Thermoplastics can usually be melted down and reused without any major loss of quality. Composites can be fractioned and used as filling materials in other materials or be disposed of.

Oils and greases

Before disposal, oil, grease and similar products must be removed and sent to an approved environmental waste treatment plant or recycling company. By utilizing gravimetric forces, oil waste can be separated into oil, water and a range of contaminants. In many cases, the oil can then be reused. Alternatively, the energy content in oil can be recovered through combustion at a plant designed for the purpose.

Rubber

Rubber can be sent to an approved environmental waste treatment plant, either for disposal or reuse for various purposes.

Rubber is present in various seals.

Other materials

Other materials are sorted and sent to an approved environmental waste treatment plant.