Transformer bushing, type GSC
Installation and maintenance guide
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</tr>
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</table>
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 of functional requirements when assembling or removing equipment where there is a risk of damage to the product or 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 tightening torque.
1.2 Hazardous working situations

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working close to high voltage.</td>
<td>Disconnect all plant power. Ground all objects at the workplace. If work must be done close to live plant components, make sure that the safety distance is in compliance with the applicable safety regulations.</td>
</tr>
<tr>
<td>Working on ladders and platforms.</td>
<td>Work must be done in accordance with the applicable safety regulations. Do not use ladders or platforms in poor weather conditions.</td>
</tr>
<tr>
<td>Working with heavy objects.</td>
<td>Do not walk under lifted objects. Make sure that heavy objects are stable before starting work.</td>
</tr>
</tbody>
</table>

1.3 Safety precautions

<table>
<thead>
<tr>
<th>Precaution</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer oil</td>
<td>Collect used transformer oil in drums. Transformer oil is dangerous. Fumes from hot oil can cause irritation to the respiratory organs and the eyes. Long and repeated contact with transformer oil can cause damage to your skin.</td>
</tr>
<tr>
<td>Waste and cleaning up</td>
<td>Clean up liquid waste with an adsorbent. Treat waste as hazardous to the environment.</td>
</tr>
<tr>
<td>Fire</td>
<td>Extinguish fires with powder, foam or carbon dioxide.</td>
</tr>
</tbody>
</table>

1.4 Competence level

Installation of the bushing should only be performed by authorized personnel.

⚠️ **CAUTION!**
Incorrect installation can lead to catastrophic failure of the transformer.
2 Product description

2.1 Design

Overview

The GSC type is a transformer bushing. It is made for immersed oil to air service. The bushing is of the dry, gas-free type, with a resin impregnated paper RIP condenser core as the primary insulation, and silicone rubber (SiR) sheds as outdoor insulation. Bushings of this design can be installed at any angle from vertical to horizontal.

The bushing is built around an aluminum or copper center tube on which the condenser core is wound. The core is wound from crepe paper with aluminum foil inserts for electrical stress control. The core is impregnated and cured in vacuum, giving a partially discharge-free bushing with low dissipation factor (tan δ). The insulator is made of composite material and has a silicone shed. The space between the condenser core and the insulator is filled with insulating gel.

On the flange there is a test tap. The outer conducting layer of the condenser core is connected to the insulated test tap. A voltage tap, $U_R = 6 \text{kV}$, is available as an option.

The GSC bushing is made for operation on the valve side of an HVDC converter transformer. As an option, it can also have an extended ground plane on the air side, for operation through a wall, for example in a HVDC converter station.

For a detailed description, please refer to the Technical guide, 1ZSC000563-AAW.
General schematics

There can be some variation depending on type and configuration.

1. Outer terminal
2. Composite insulator (SiR)
3. Mounting flange
4. RIP condenser core
5. Test tap/voltage tap
6. Ground shield
Test tap

The bushing has a test tap that is connected to the outermost conductive layer of the condenser core. The test tap is used to measure the bushing insulation by capacitance and dissipation factor. The cover connects the outermost conductive layer to ground, and must always be installed when the bushing is energized.

The maximum one minute test voltage for this test tap is $2 \text{kV}_{\text{rms}}$. The test tap can be used as a power source, if it is connected to an external capacitance. The operating voltage is limited to 600 V.

**CAUTION!**

Do not energize the bushing without a test adapter or the cover installed. The bushing is grounded through the cover to prevent damage to the bushing.

![Diagram of test tap components]

1. Stud
2. Cover
3. Grounding spring
4. O-ring
Voltage tap

The voltage tap is available as an option, instead of the test tap.

The bushing has a voltage tap that is connected to the second outermost conductive layer of the condenser core. The voltage tap is used to measure the bushing insulation by capacitance and dissipation factor. The cover connects the outermost conductive layer to ground, and must always be installed when the bushing is energized.

The maximum one minute test voltage for this voltage tap is $2 \text{kV}_{\text{rms}}$. The voltage tap can be used as a power source, if it is connected to an external capacitance. The operating voltage is limited to 6 kV.

⚠️ CAUTION!

Do not energize the bushing without a test adapter or the cover installed. The cover connects the outermost conductive layer to ground and will prevent damage to the bushing.

Test adapter, 2769 522-C, optional equipment

The test adapter 2769 522-C is available for permanent connection to measuring circuits. Please refer to Test adapter – Technical guide 1ZSC000563-ACS and Installation and maintenance guide 1ZSC000563-ACD.
## 2.2 Technical specifications

### 2.2.1 General specifications

Refer to the table for the standard technical specifications of the bushing. For conditions exceeding the specifications, please contact ABB.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application</strong></td>
<td>Transformers</td>
</tr>
<tr>
<td><strong>Classification</strong></td>
<td>Transformer bushing • Resin impregnated paper, capacitance graded, oil immersed.</td>
</tr>
<tr>
<td><strong>Ambient temperature limits</strong></td>
<td>-40 °C to +40 °C. Other temperatures on request, subject to agreement. Maximum ambient temperature +60 °C when used in valve halls, or project specific.</td>
</tr>
<tr>
<td><strong>Maximum altitude of site</strong></td>
<td>1000 m (Bushings for other altitudes can be provided on request.)</td>
</tr>
<tr>
<td><strong>Level of rain and humidity</strong></td>
<td>1-2 mm rain/minute horizontally and vertically, according to IEC 60060-1 and IEEE Std 4.</td>
</tr>
<tr>
<td><strong>Maximum pollution level</strong></td>
<td>According to the specific creepage distance, and IEC 60815.</td>
</tr>
<tr>
<td><strong>Immersion medium</strong></td>
<td>Transformer oil. The maximum daily mean oil temperature is current-dependent and project specific.</td>
</tr>
<tr>
<td><strong>Maximum pressure of medium</strong></td>
<td>( p_g ) 100 kPa (( p_g ) = relative to ambient pressure).</td>
</tr>
<tr>
<td><strong>Angle of installation</strong></td>
<td>From horizontal to vertical.</td>
</tr>
<tr>
<td><strong>Test tap</strong></td>
<td>According to IEEE potential tap type A. ( U_r ) = max 600 V. Voltage tap ( U_r ) = 6 kV as option.</td>
</tr>
<tr>
<td><strong>Capacitance ( C_2 ) of test tap</strong></td>
<td>&lt;5000 pF</td>
</tr>
<tr>
<td><strong>Conductor</strong></td>
<td>Center-tube conductor.</td>
</tr>
<tr>
<td><strong>Markings</strong></td>
<td>Conforming to IEC/IEEE.</td>
</tr>
</tbody>
</table>

### 2.2.2 Mechanical loading

**Maximum permitted static load on the outer terminal**

The load must be applied at the midpoint (4) of the outer terminal or below. The total cantilever load must be perpendicular to the bushing axis.

In the axial direction (3), the bushing can withstand a static load of 20 kN.

**NOTE!**

The loads described in this section are static loads, for dynamic loads such as earthquakes and extreme weather conditions, please contact your ABB sales representative.
1. Maximum cantilever load, vertical (0°)
2. Maximum cantilever load, horizontal (90°)
3. Maximum axial static load
4. Load applied at the midpoint

<table>
<thead>
<tr>
<th>Type</th>
<th>Maximum cantilever load in operation at installation angle (N)</th>
<th>Maximum cantilever test load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0°</td>
<td>90°</td>
</tr>
<tr>
<td>GSC 140E</td>
<td>2000</td>
<td>1300</td>
</tr>
<tr>
<td>GSC 150</td>
<td>2800</td>
<td>2000</td>
</tr>
<tr>
<td>GSC 200</td>
<td>3200</td>
<td>2000</td>
</tr>
<tr>
<td>GSC 300</td>
<td>3300</td>
<td>2000</td>
</tr>
<tr>
<td>GSC 300E</td>
<td>3300</td>
<td>2000</td>
</tr>
<tr>
<td>GSC 400</td>
<td>6500</td>
<td>4000</td>
</tr>
<tr>
<td>GSC 450S</td>
<td>6500</td>
<td>4000</td>
</tr>
<tr>
<td>GSC 450E</td>
<td>6500</td>
<td>4000</td>
</tr>
<tr>
<td>GSC 500</td>
<td>6500</td>
<td>4000</td>
</tr>
<tr>
<td>GSC 500E</td>
<td>6500</td>
<td>4000</td>
</tr>
</tbody>
</table>

**Maximum permitted torque on the outer terminal**

The maximum torque that is permitted on the outer terminal.

<table>
<thead>
<tr>
<th>Type</th>
<th>Maximum torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC 150/200/300/300E/400</td>
<td>200 Nm</td>
</tr>
<tr>
<td>GSC 140E/450S/450E/500/500E</td>
<td>250 Nm</td>
</tr>
</tbody>
</table>
3 Delivery

3.1 Incoming inspection

- Make sure that all items have been delivered, refer to the packing list.
- Carefully inspect the bushings for shipping damage.

**NOTE!**
The bushing has been routine tested in oil, and there can be small quantities of oil remaining on the oil-side of the bushing. Vaseline is used for lubrication of threads, and at some temperatures Vaseline can appear as oil.

3.2 Transportation

- The bushing must be transported in the transport box.
- Carefully inspect the bushing for damage after transportation.

3.3 Storage

**Short and long term storage**

- The transport container must be attached to the bushing during storage.
- Replace the drying agent, if it has been exposed to the atmosphere.
- The bushing can be stored outdoors, if it is in the transport box.
  Keep the transport box protected from water, when the bushing is stored outdoors.
- Keep the transport box in the horizontal position.

![Transport container diagram]

1. Transport container
3.4 Lifting

3.4.1 Lifting the transport box

Overview

1. Center of gravity
2. Soft lifting slings
3. Forklift lifting points

Procedure

1. Make sure that the crane and the soft lifting slings are approved for the total weight of the transport box and bushing. Refer to the weight in the packing list.

2. Attach soft lifting slings (2).

   **NOTE!**
   There are markings on the transport box were to place the soft lifting slings.

3. Make sure that the angle of the soft lifting sling is not more than 20°.

4. Carefully lift the transport box.

5. Set down the transport box on a flat surface.

End of instruction
3.4.2 Lifting the bushing out of the transport box

Overview

Procedure

1. Make sure that the crane is approved for lifting the weight of the bushing. Refer to the weight on the rating plate.

2. Open the transport box.
   
   **NOTE!**
   The cover is attached with bolts.

3. Remove the support blocks from the transport box and put them on the ground.
   
   **CAUTION!**
   Make sure that the ground is flat.

   **NOTE!**
   If there are no support blocks in the transport box, use soft bedding.

4. Attach a soft lifting sling to the bottom end housing, as close to the flange as possible, and then to the crane hook.
   
   **CAUTION!**
   Do not put the soft lifting slings on the silicone insulator, damage will occur.

5. Attach a soft lifting sling to the outer terminal and then to the crane hook.
   
   **CAUTION!**
   Attach the soft lifting sling as close to the top housing as possible, or damage will occur.
6. Carefully lift the bushing.

7. Lower the bushing onto the support blocks.

**NOTE!**
If there are no support blocks then use soft bedding.

End of instruction
# 4 Installation

## 4.1 Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Part number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifting tool</td>
<td>9760 667-A</td>
<td>GSC 150/200/300/300E/400</td>
</tr>
<tr>
<td></td>
<td>1ZSC004867-AAA</td>
<td>GSC 140E/450S/450E/500/500E</td>
</tr>
<tr>
<td>Soft bedding</td>
<td>-</td>
<td>E.g. rubber mat or wood board</td>
</tr>
<tr>
<td>Soft lifting slings</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pull-through cord</td>
<td>9760 669-A</td>
<td>With M8 terminal. For assembly and disassembly of the draw rod.</td>
</tr>
<tr>
<td>Torque wrench key for hex socket screws, 16 mm (M10) and 13 mm (M8), torque 20 to 40 Nm.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wrench for hexagon head screws 30 mm or adjustable wrench for 30 mm bolts or larger.</td>
<td>-</td>
<td>For the test tap cover.</td>
</tr>
<tr>
<td>Shackles</td>
<td>-</td>
<td>To fit Ø 25 mm holes, for connection of the soft lifting slings to the bushing flange.</td>
</tr>
<tr>
<td>Box spanner</td>
<td>9760 669-B</td>
<td>For removal, and installation of the bottom contact. Draw-rods system.</td>
</tr>
<tr>
<td>Tackle</td>
<td>-</td>
<td>For installation of the bushing at a specific angle.</td>
</tr>
</tbody>
</table>

## 4.2 Consumables

<table>
<thead>
<tr>
<th>Item</th>
<th>Brand</th>
<th>ABB part number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil based Vaseline</td>
<td>Fuchs</td>
<td>-</td>
<td>For treatment of contact surfaces. Does not react with transformer oil.</td>
</tr>
<tr>
<td>Mobilgrease 28</td>
<td>MOBIL</td>
<td>-</td>
<td>Lubricate and protect outer terminal gasket.</td>
</tr>
<tr>
<td>Molykote Multilub</td>
<td>Dow Corning</td>
<td>-</td>
<td>For lubrication of draw-rod threads and bolts on the outer terminal.</td>
</tr>
<tr>
<td>Thread-locking fluid grade 40</td>
<td>-</td>
<td>1269 0014-408</td>
<td>High strength thread-locking fluid, permanent locking.</td>
</tr>
</tbody>
</table>
4.3 General preparations

4.3.1 Preparations overview

Before installing the bushing, the transport container and the outer terminal must to be removed and the lifting tool installed.

4.3.2 Removing transport container and outer terminal

Procedure for removing transport container and outer terminal

1. Make sure that the crane can lift the bushing. Refer to net weight in the packing list.

2. Attach soft lifting slings arround the transport container to the crane hook.

3. Remove the transport container.

NOTE!
Be carefull not to damage the condenser core when removing the transport container.
4. Remove the M10 bolts (8) and washers (9), and then remove the outer terminal (7).

**NOTE!**
Keep the outer terminal (7), bolts (8) and washers (9), they will be used again.

---

4.3.3 Lifting type GSC 140E/150/200/300/300E/400

**Overview**

When lifting the bushing GSC 140E/150/200/300/300E/400 for installation at vertical angle, arrange the lifting according to position (6) in the figure.

When lifting the bushing for installation at a specific angle, use a shackle and arrange according to position (5) in the figure. The lifting tool must be aligned with the lifting eye in the flange.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Lifting tool</td>
</tr>
<tr>
<td>2.</td>
<td>Soft bedding, e.g. rubber mat or woodboard</td>
</tr>
<tr>
<td>3.</td>
<td>Lifting eye</td>
</tr>
<tr>
<td>4.</td>
<td>Shackle</td>
</tr>
<tr>
<td>5.</td>
<td>Lifting with a specific angle</td>
</tr>
<tr>
<td>6.</td>
<td>Lifting vertical</td>
</tr>
</tbody>
</table>

**Procedure for lifting type GSC 140E/150/200/300/300E/400**

1. Install the lifting tool (1) with the bolts (8) and the washers (9).

**NOTE!**
For the GSC 150/200/300/300E/400 the 9760 667-A lifting tool is used.

**NOTE!**
For the GSC 140E the 1ZSC004867-AAA lifting tool is used.

**NOTE!**
Align the lifting tool with the lifting eyes on the flange.

**Torque**
40 ±4 Nm
2. For vertical installation: attach soft lifting slings (6) from the lifting tool (1) to the crane hook.

3. For installation at a specific angle: also attach soft lifting slings with a shackle (4) from the flange to the crane hook.

4. Align the crane hook with the lifting tool on the bushing.

5. Carefully lift the bushing.

   **CAUTION!**
   Make sure that the bushing does not rotate.

   **NOTE!**
   Place a soft bedding under the condenser core bottom.

6. Adjust the shackle (4) until the bushing flange has the same angle as the transformer flange.

End of instruction

### 4.3.4 Lifting type GSC 450S/450E/500/500E

**Overview**

When lifting the bushing GSC 450S/450E/500/500E for installation at vertical angle, arrange the lifting according to position (6) with the soft lifting slings going through the lifting tool down to the lifting eyes at the flange.

When lifting the bushing for installation at a specific angle, use a shackle and arrange according to position (5) in the figure. The lifting tool must be aligned with the lifting eye in the flange.
1. Lifting tool
2. Soft bedding, e.g. rubber mat or wood board
3. Lifting eye
4. Shackel
5. Lifting with a specific angle
6. Lifting vertical

Procedure for lifting type GSC 450S/450E/500/500E

1. Install the lifting tool (1) with the bolts (8) and the washers (9).

**NOTE!**
For the GSC 450S/450E/500/500E the 1ZSC004867-AAA lifting tool is used.

**NOTE!**
Align the lifting tool with the lifting eyes on the flange.

**Torque**
40 ±4 Nm
2. For vertical installation: attach soft lifting slings from the lifting eyes (3), through the lifting tool (1) to the crane hook.

3. For installation at a specific angle: also attach soft lifting slings with a shackle (4) from the flange to the crane hook.

4. Align the crane hook with the lifting tool on the bushing.

5. Carefully lift the bushing.

   **CAUTION!**
   Make sure that the bushing does not rotate.

   **NOTE!**
   Place a soft bedding under the condenser core bottom.

6. Adjust the shackle (4) until the bushing flange has the same angle as the transformer flange.

End of instruction

### 4.4 Installation with draw rod at the transformer factory

#### Overview

The draw rod is usually installed in the bushing when it is delivered from ABB, the first step at the transformer factory is therefore to remove it.
1. Upper draw rod
2. Flexible pull-through cord
3. Lower draw rod with bottom contact
4. Bottom contact
5. Bushing

Procedure

1. Apply Vaseline to the screw thread on the pull-through cord (12), then connect it to the draw rod.

   NOTE!
   Or use a lubricant with equal properties to Vaseline.
2. Remove the M16 nut (10) on the draw rod.

3. Pull down the draw rod from the bottom end of the bushing, and disassemble it at the lower joint (8).

**NOTE!**
The upper screw thread (7) locked with thread-locking fluid 1269 0014-408.

4. Carefully clean the bottom end of the bushing, and the inside of the center hole. Look for damage.

5. Remove the transformer cover (13) from the transformer (11).
6. Install the winding cables to the bottom contact.

**CAUTION!**
Make sure that there is no tension in the winding cables. Tension in the winding cables will cause damage to the bottom contact.

7. Only for the GSC 140E/150/200/300/400/450S. Make sure the compensating device (14) is still in the bushing.

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

9. Connect the draw rod (1) to the lower draw rod (4).
10. Hold the pull-through cord (12) in tension, while lowering the bushing onto the transformer.

**NOTE!**
Put plastic sleeves on two or three of the stud bolts, to guide the flange and to prevent damage to the stud bolts.

11. Install the nuts and washers. Tighten the nuts in a crosswise sequence.

**Torque**
Please refer to the transformer documentation.

12. Install the washer and nut on the draw rod.

**NOTE!**
Apply a generous amount of Molykote Multilub on the nut, washer and drawrod bolt. Remove any excess Molykote Multilub with a rag.

13. Remove the lifting gear and the pull-thorough cord.
14. Tighten the nut.

15. Tighten the draw-rod nut, refer to *Hydraulic tightening of the draw-rod nut, page 33*, or *Manual tightening of the draw-rod nut, page 36*.

End of instruction
4.5 Installation with draw rod at site

1. Upper draw rod
2. Flexible pull-through cord
3. Lower draw rod with bottom contact
4. Bottom contact
5. Bushing

Procedure

NOTE!
This procedure is only valid if the lower draw rod with bottom contact (5) is already installed in the transformer.

1. Apply Vaseline to the thread on the pull-through cord (12), and then connect it to the draw rod.

NOTE!
Or use a lubricant with equal properties to Vaseline.
2. Remove the M16 nut (10).

3. Carefully clean the bottom end of the bushing, and the inside of the center hole. Look for damage.

4. Pull down the upper draw rod (1) from the bottom end of the bushing.

5. Remove the transport cover (13) from the transformer (11) and the lower draw rod (4).

6. Only for the GSC 140E/150/200/300/300E/400/450S. Make sure the compensating device (14) is still in the bushing.

7. Lift the bushing to a position above the installation opening on the transformer.

CAUTION!
Make sure that there are installation markings on the bushing flange. The bushing must always be installed in the same direction on the transformer.
8. Apply locking fluid on the threads (8) on the lower draw rod (4).

**NOTE!**
Use thread-locking fluid 1269 0014-408.

9. Connect the upper draw rod (1) to the lower draw rod (4).

10. Hold the pull-through cord (12) in tension, while lowering the bushing onto the transformer.

**NOTE!**
Put plastic sleeves on two or three of the stud bolts to guide the flange and to prevent damage to the stud bolts.
11. Install the nuts and washers. Tighten the nuts in a crosswise sequence.

12. Install the washer and nut on the draw rod.

**NOTE!**
Apply a generous amount of Molykote Multilub on the nut, washer and draw rod bolt. Remove any excess Molykote Multilub with a rag.

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

14. Tighten the nut.

**Torque**
Please refer to the transformer documentation.

**Torque**
10 Nm (GSC 140E/150/200/300/300E/400/450S)
20 Nm (GSC 450E/500/500E)
15. Tighten the draw-rod nut, refer to *Hydraulic tightening of the draw-rod nut, page 33*, or *Manual tightening of the draw-rod nut, page 36*.

End of instruction

### 4.6 Hydraulic tightening of the draw-rod nut

**Overview**

This procedure requires the draw-rod nut, washer and threads of the draw rod to be correctly lubricated. The draw rod will not get the correct tension if the fasteners are not correctly lubricated, this can cause the bushing to fail.

**Procedure**

1. Measure the distance (a).

   **NOTE!**

   The bushing is delivered with an information sheet that specifies the draw-rod extension (b-a), and the torque of the draw-rod nut. These values are measured when the bushing is manufactured, and are unique to every unit.
2. Install the shaft (37) on the draw rod (35), and put the box-spanner (13) on the shaft (37).

3. Make sure that more than 10 mm of the threads on the upper draw rod (35) are used.

4. Put the hydraulic jack (38) on the shaft (37), and install the nut (44) but do not tighten it.
5. Pull the draw rod with a force according to the table.

**DANGER!**
Apply the hydraulic pressure carefully. Incorrectly used high pressure hydraulics can break with explosive force.

**NOTE!**
It is not necessary to compensate for variations in ambient temperature.

<table>
<thead>
<tr>
<th>Type</th>
<th>Force with CT 600 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC 140E</td>
<td>37.0 kN</td>
</tr>
<tr>
<td>GSC 150</td>
<td>34.5 kN</td>
</tr>
<tr>
<td>GSC 200</td>
<td>37.0 kN</td>
</tr>
<tr>
<td>GSC 300</td>
<td>36.3 kN</td>
</tr>
<tr>
<td>GSC 300E</td>
<td>37.0 kN</td>
</tr>
<tr>
<td>GSC 400</td>
<td>37.3 kN</td>
</tr>
<tr>
<td>GSC 450S</td>
<td>37.3 kN</td>
</tr>
<tr>
<td>GSC 450E</td>
<td>40.0 kN</td>
</tr>
<tr>
<td>GSC 500</td>
<td>40.0 kN</td>
</tr>
<tr>
<td>GSC 500E</td>
<td>40.0 kN</td>
</tr>
</tbody>
</table>

6. Turn the nut on the upper draw rod (35) with the box-spanner, tighten with your hand.

7. Loosen the nut (44).

8. Turn the shaft (37) counter clockwise to remove the shaft-socket from the upper draw rod (35).
9. Remove the hydraulic jack (38) from the bushing.

10. Make sure that the draw-rod extension is within the tolerances:
   1. Measure the distance (b).
   2. Calculate the extension of the draw rod: (b) minus (a).
   3. Compare the calculated value (b-a) with the dimension in the table.

End of instruction

4.7 Manual tightening of the draw-rod nut

Overview

This procedure requires the draw-rod nut and threads of the draw rod to be correctly lubricated. The draw rod will not get the correct tension if the fasteners are not correctly lubricated, this can cause the bushing to fail.

Procedure

1. Make sure that the draw-rod nut, and threads of the draw rod are correctly lubricated, and that the draw-rod nut is tightened to 10 Nm.
2. Measure the distance (a).

**NOTE!**
The bushing is delivered with an information sheet that specifies the measurement (b-a), and the torque of the draw-rod nut. These values are measured when the bushing is manufactured, and are unique to every unit.

3. Turn the nut clockwise until you get the correct extension (b).

Distance (b) = (a) + extension, refer to the table.

**CAUTION!**
Make sure that you do not overtighten the nut. Use a torque wrench set to max. torque, refer to the table.

**NOTE!**
One turn of the nut corresponds to a 2 mm extension of the draw rod.

<table>
<thead>
<tr>
<th>Type</th>
<th>Extension</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC 140E</td>
<td>8.5 mm</td>
<td>70–140 Nm</td>
</tr>
<tr>
<td>GSC 150</td>
<td>7.0 mm</td>
<td>70–140 Nm</td>
</tr>
<tr>
<td>GSC 200</td>
<td>7.8 mm</td>
<td>70–140 Nm</td>
</tr>
<tr>
<td>GSC 300</td>
<td>8.8 mm</td>
<td>70–140 Nm</td>
</tr>
<tr>
<td>GSC 300E</td>
<td>10.3 mm</td>
<td>70–140 Nm</td>
</tr>
<tr>
<td>GSC 400</td>
<td>12.0 mm</td>
<td>70–140 Nm</td>
</tr>
<tr>
<td>GSC 450S</td>
<td>12.0 mm</td>
<td>70–140 Nm</td>
</tr>
<tr>
<td>GSC 450E</td>
<td>9.0 mm</td>
<td>Max. 160 Nm</td>
</tr>
<tr>
<td>GSC 500</td>
<td>9.0 mm</td>
<td>Max. 160 Nm</td>
</tr>
<tr>
<td>GSC 500E</td>
<td>9.0 mm</td>
<td>Max. 160 Nm</td>
</tr>
</tbody>
</table>

End of instruction
4.8 Installation of the outer terminal

Procedure

1. Carefully clean the contact and gasket surfaces with a soft cloth.

   ![CAUTION!]
   Do not use a wire brush on aluminium surfaces, or zinc coated surfaces. A wire brush can make scratches in the surfaces.

2. Carefully clean the contact and gasket surfaces with a soft cloth, and then apply Mobilgrase 28 to the O-ring (3).
   1. Carefully clean the contact surface and gasket surface with a soft cloth.
   2. Apply Vaseline to the contact surface.
   3. Apply Mobilgrease 28 to the gasket surface and O-ring (3).

   ![CAUTION!]
   Do not use a wire brush on the inner contact surfaces of aluminum outer terminals.

   ![NOTE!]
   Or use a lubricant with equal properties to Mobilgrease 28.

   ![NOTE!]
   When the outer terminal (5) is installed at site for grid operation, replace the used O-ring (3) with a new O-ring. A new O-ring is supplied with the bushing.
3. Assemble the tightening ring (4), the O-ring (3), and the outer terminal (5).

4. Apply Molykote Multilub to the washers, and to the threads and the shank of the M10 bolts (2).

   NOTE!
   Or use a lubricant with equal properties to Molykote Multilub.

5. Install the M10 bolts (2) and plain washers.
   Tighten the bolts in a crosswise sequence.

   CAUTION!
   Do NOT use an impact driver / wrench!
6. Install the M8 bolts (1), conical spring-washers and plain washers.
   Tighten the bolts in a crosswise sequence.

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

   ![Image of M8 bolts with washers]

   **Torque**
   20 ±2 Nm

7. Install the external connections. Refer to the documentation from the supplier of the external connection.

   End of instruction
4.9 Grounding of the bushing flange

Overview

The bushing flange must be grounded to the transformer tank. This prevents electrical discharge between the bushing flange and the transformer tank under normal service conditions.

There are two alternatives.

DANGER!
Make sure that the grounding is correct. An unsatisfactory grounding can cause damage to equipment, or death to personnel.

Procedure with a cone point set screw

1. Apply a large quantity of Mobilgrease 28 to the cone point set screw (13).
   
   CAUTION!
   The quality of the cone point set screw is important, stainless steel of A4-80 quality is recommended.

   NOTE!
   Or use a lubricant similar to Mobilgrease 28.

2. Install the cone point set screw (13).
   
   NOTE!
   The cone point of the set screw penetrates the paint. This makes an electrical connection between the bushing and the transformer tank, keeping them at the same potential.

   Torque
   M12: 40 Nm

End of instruction
Procedure with a flexible cable

1. Clean the contact surfaces.

2. Put a flexible cable (14) between the grounding hole in the bushing flange and a grounding point on the transformer.

3. Apply a large quantity of Mobilgrease 28 to the bolt (13).

   **CAUTION!**
   - The quality of the bolt is important, stainless steel of A4-80 quality is recommended.

   **NOTE!**
   - Or use a lubricant similar to Mobilgrease 28.

4. Install the bolt (13).

   **Torque**
   - M12: 40 Nm

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

   **NOTE!**
   - This makes an electrical connection between the bushing and transformer tank, keeping them at the same potential.

End of instruction
4.10 Flashover distance

The distance to external objects from the top of the bushing is very important for the safe operation of the bushing.

A clear area around the high voltage end of the bushing must be maintained, to prevent flashover or other disturbances. The radius of the area corresponds to the arcing distance of the bushing insulator.

**CAUTION!**
Objects in the flashover distance can cause a spontaneous electrical discharge.

1. Flashover distance

<table>
<thead>
<tr>
<th>Type</th>
<th>Flashover distance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC 140E</td>
<td>1110</td>
</tr>
<tr>
<td>GSC 150</td>
<td>1960</td>
</tr>
<tr>
<td>GSC 200</td>
<td>2045</td>
</tr>
<tr>
<td>GSC 300</td>
<td>3540</td>
</tr>
<tr>
<td>GSC 300E</td>
<td>2855</td>
</tr>
<tr>
<td>GSC 400</td>
<td>4230</td>
</tr>
<tr>
<td>GSC 450S</td>
<td>3760</td>
</tr>
<tr>
<td>GSC 450E</td>
<td>5100</td>
</tr>
<tr>
<td>GSC 500</td>
<td>5100</td>
</tr>
<tr>
<td>GSC 500E</td>
<td>5100</td>
</tr>
</tbody>
</table>
5 Commissioning

5.1 Waiting time before energization

Waiting times after oil-filling of the transformer

Some waiting time is necessary after the transformer has been oil-filled, before the bushing is energized. The reason for this is that air bubbles stick to the bushings surface when the transformer is filled with oil, and flashovers and partial discharges can form in the bubbles. Thus, it is important to let the necessary waiting time pass, to make sure that all the air bubbles have risen to the surface of the oil before the bushing is energized. Refer to the table.

<table>
<thead>
<tr>
<th>The transformer is oil-filled with</th>
<th>Necessary waiting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>The vacuum process</td>
<td>No waiting time is necessary, air bubbles does not form in vacuum. Refer to the transformer manufacturers instructions.</td>
</tr>
<tr>
<td>Gas-saturated transformer oil</td>
<td>After the oil-filling process has been completed, wait for 24 hours before energizing the transformer.</td>
</tr>
<tr>
<td>De-gassed transformer oil</td>
<td>After the oil-filling process has been completed, wait for 6 hours before energizing the transformer.</td>
</tr>
<tr>
<td>A reduced oil-level</td>
<td>After the oil-level has been restored, wait 24 hours before energizing the transformer.</td>
</tr>
</tbody>
</table>

5.2 Recommended tests before energization

5.2.1 Overview

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

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

5.2.2 Tightness test between transformer and bushing flange

Many different methods can be used, and we thus refer to the instructions given by the company responsible for field erection.

For example, the tightness of the seal between the transformer and the bushing flange can be examined when the transformer is oil-filled, with chalk or paper strips.
5.2.3 Tightness test of bushing outer terminal

Overview

Because the outer terminal is often situated above the oil-level of the transformer oil expansion system, a leak at the outer terminal is serious. Water could enter directly into the transformer insulation. It is thus recommended to do a tightness test after installation of the bushing, both with vacuum and pressure.

Different methods can be used, and ABB refers to the instructions given by the company responsible for the field erection of the bushing.

Example procedure

1. Put tracer gas into the center tube before installation of the outer terminal.

   **NOTE!**
   The oil-level of the transformer must be above the bottom end of the bushing, but below the bushing flange.

2. Increase the oil-level to just below the bushing flange, to raise the pressure in the center tube.

3. Find leaking gas with gas detector (sniffer) near the gasket.

5.2.4 Measurement of capacitance and dissipation factor

Overview

After installation of the bushing, it is recommended to measure the capacitance values for future reference, such as repairs, service etc. This can be done on an installed bushing because it has an insulated test tap. Refer to 2750 515-142, “Bushing diagnostics and conditioning”.

- \( C_1 \) is the capacitance between the test tap and the outer terminal.
- \( C_2 \) is the capacitance between the test tap and ground.

**NOTE!**

The transport container must be removed before measuring the capacitance and dissipation factor (\( \tan \delta \)).
Nominal capacitance

The capacitance ($C_2$) depends on the transformer, and it is not possible to give a nominal value that is valid for all service conditions. Thus, it is important to measure and record the capacitance ($C_2$) for future reference, such as repairs, service etc.

<table>
<thead>
<tr>
<th>Type</th>
<th>Space for CT = 600 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$C_1$ (pF)</td>
</tr>
<tr>
<td>GSC 140E</td>
<td>1210</td>
</tr>
<tr>
<td>GSC 150</td>
<td>769</td>
</tr>
<tr>
<td>GSC 200</td>
<td>617</td>
</tr>
<tr>
<td>GSC 300</td>
<td>632</td>
</tr>
<tr>
<td>GSC 300E</td>
<td>821</td>
</tr>
<tr>
<td>GSC 400</td>
<td>612</td>
</tr>
<tr>
<td>GSC 450S</td>
<td>648</td>
</tr>
<tr>
<td>GSC 450E</td>
<td>850</td>
</tr>
<tr>
<td>GSC 500</td>
<td>799</td>
</tr>
<tr>
<td>GSC 500E</td>
<td>915</td>
</tr>
</tbody>
</table>

Dissipation factor, $\tan \delta$

The dissipation factor varies with the temperature of the bushing core, and thus the measured dissipation factor must be multiplied with the correction factor given below.

<table>
<thead>
<tr>
<th>Bushing core temperature °C</th>
<th>Correction factor to 20 °C (IEC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>0.76</td>
</tr>
<tr>
<td>3-7</td>
<td>0.81</td>
</tr>
<tr>
<td>8-12</td>
<td>0.87</td>
</tr>
<tr>
<td>13-17</td>
<td>0.93</td>
</tr>
<tr>
<td>18-22</td>
<td>1.00</td>
</tr>
<tr>
<td>23-27</td>
<td>1.07</td>
</tr>
<tr>
<td>28-32</td>
<td>1.14</td>
</tr>
<tr>
<td>33-37</td>
<td>1.21</td>
</tr>
<tr>
<td>38-42</td>
<td>1.27</td>
</tr>
<tr>
<td>43-47</td>
<td>1.33</td>
</tr>
<tr>
<td>48-52</td>
<td>1.37</td>
</tr>
<tr>
<td>53-57</td>
<td>1.41</td>
</tr>
<tr>
<td>58-62</td>
<td>1.73</td>
</tr>
<tr>
<td>63-67</td>
<td>1.43</td>
</tr>
<tr>
<td>68-72</td>
<td>1.42</td>
</tr>
<tr>
<td>73-77</td>
<td>1.39</td>
</tr>
<tr>
<td>78-82</td>
<td>1.35</td>
</tr>
<tr>
<td>83-87</td>
<td>1.29</td>
</tr>
</tbody>
</table>

Procedure

1. De-energize the transformer.
2. Disconnect the external connections from the outer terminal of the bushing.

3. Remove the cover (2).

<table>
<thead>
<tr>
<th>Part</th>
<th>Article number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover</td>
<td>2769522-M</td>
</tr>
<tr>
<td>O-ring</td>
<td>1ZSC0044442-CAK</td>
</tr>
</tbody>
</table>

4. Connect the measuring equipment.
   1. Connect the low voltage cable to the stud (1).
   2. Connect the high voltage cable to the outer terminal.
   3. Connect the ground cable to the bushing flange.

5. Measure the capacitance ($C_1$) between the outer terminal and the stud (1).
   - Record the capacitance ($C_1$) for future reference.

   **NOTE!**
   Refer to the table for the nominal capacitance ($C_1$), **Nominal capacitance**, page 47.

6. Measure the capacitance ($C_2$) between the stud (1) and the flange.
   - Record the capacitance ($C_2$) for future reference.

7. Measure the dissipation factor:
   1. Start the measurements with a low sensitivity setting on the measuring bridge.
   2. Gradually increase the sensitivity setting on the measuring bridge to the highest possible.
   3. Calculate the dissipation factor with the correction factor, refer to **Dissipation factor, tan δ**, page 47.

   **NOTE!**
   In some cases, external interference can make it difficult to set the measuring bridge to zero.
8. Install the cover (2).

**CAUTION!**

The test tap is not self-grounding!

The bushing can be destroyed if the test tap is not grounded. Because the capacitance ($C_2$) 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.

**CAUTION!**

Do not energize the bushing without the cover or a test adapter installed. The cover connects the outermost conductive foil to ground and will prevent damage to the bushing.

**CAUTION!**

Make sure that the cover is correctly installed with the O-ring in place, when the bushing is not in use. The purpose is to prevent dust and water from entering the tap.

9. Connect the outer terminal of the bushing to the external connections.

End of instruction

### 5.2.5 Measurement of through-resistance

**Overview**

The method to use for measuring the through-resistance depends on the design of the transformer. In general, a current is applied from bushing to bushing. The voltage drop from the outer terminal to outer terminal is measured. The resistance is calculated with Ohm's law, $R=U/I$.

(R: total circuit resistance, U: measured voltage drop, I: through-current).

The total through-resistance is the sum of the transformer winding, lead resistance, the bushing conductor, and contact resistance. The additional resistance from the bushing conductor should not be more than 150 μΩ. Because the through-resistance of the HV winding of a typical power transformer is in the order of 0.1 to 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.

Small faults in the current path can only be detected by making sensitive measurements across each connection point, or by measuring the temperature increase during operation with an infrared sensitive camera (thermovision).

The through-resistance of an installed bushing can only be measured from the outer terminal of one bushing, to the outer terminal of the other bushing on the same transformer winding. The through-resistance will include the resistance of both bushings, all connections and the transformer winding.

Because the result of the measurement depends on the temperature and the accuracy with which the temperature can be measured, this can be a source of errors.

**Procedure**

1. Record the temperature of the transformer winding.

   **NOTE!**

   The resistance of metals depends on their temperature. Because the transformer winding usually dominates the total resistance, the average winding temperature at the time of measurement must be recorded.

2. Measure the through-resistance from outer terminal to outer terminal.
3. Calculate the measured resistance to the reference temperature. Then compare the calculated resistance to the reference resistance.

   A difference of less than 2% is acceptable.

   **NOTE!
   The transformer manufacturer gives the reference temperature for through-resistance measurements.

4. If the calculated difference of resistance is more than 2% from the reference resistance:
   1. Make sure that the external connections have low resistance, and make sure that the outer terminal and the internal connections are correctly installed.
   2. Measure the through-resistance again.

5. If the calculated difference of resistance again is more than 2%:
   • Wait 24 hours and do steps 1 through 5 again.

   End of instruction
6 Maintenance

6.1 Recommended maintenance

General
The bushings are maintenance free, no regular maintenance is necessary.

DANGER!
Risk of electrocution!
Do not go near the bushing while it is energized, or ungrounded. High voltages can kill you.
Make sure that the bushing is de-energized, and grounded before you do work on it.

Cleaning of the insulator surface
If the insulator is exposed to very high pollution, it can be necessary to clean the surface. Remove the pollution with a moist cloth. If necessary, put isopropyl alcohol on the cloth.

DANGER!
1,1,1-Trichloroethane or Methyl-chloride are not recommended as detergents, because they are dangerous to persons and the environment.

CAUTION!
Do not wash the insulators with a high pressure water jet. This can cause damage to the insulators.

Measurement of capacitance and dissipation factor
Please refer to Measurement of capacitance and dissipation factor, page 46.

Thermovision (infrared camera) check for local overheating on connectors
At the maximum rated current, the bushing outer terminal normally operates at a temperature of about +35 °C to +45 °C above the ambient temperature. Significantly higher temperatures can be a sign of bad connections, especially at lower current loading.

Checking of oil leakage
Make a visual inspection for oil leakage during regular station supervision.

After repairs
ABB recommends that the capacitance is measured after repairs have been done, after maintenance of connected equipment, or after work near the bushing is completed.

It is important to compare the capacitance before energization with the capacitance that was measured at commissioning. A change in capacitance gives indication of a fault. Refer to Measurement of capacitance and dissipation factor, page 46.
7 Re-packing

7.1 Re-packing of the bushing

Overview

Procedure

1. Install the transport container (1):
   1. Replace the drying agent in the transport container (1).
   2. Install the gasket (2).
   3. Carefully put the transport container on the bushing, and install the bolts.

   CAUTION!
   Make sure that the transport container does not cause damage to the condenser core.

   NOTE!
   The transport container has to be ordered separately.

2. Install the outer terminal. Refer to Installation of the outer terminal, page 38.
3. Lift the bushing. Refer to *Lifting the bushing out of the transport box, page 15.*

4. Lower the bushing into the transport box.

   **CAUTION!**
   Make sure that the support blocks are in the correct positions in the transport box.

   **CAUTION!**
   Make sure that the test tap does not make contact with the transport box, or other objects.

5. Attach the bushing to the transport box in the same way as when it was delivered.

   **CAUTION!**
   Make sure that the bushing cannot move or rotate in the transport box.

6. Close the transport box.

   **NOTE!**
   Refer to *Lifting the transport box, page 14 and Transportation, page 13.*

End of instruction
8 Spare parts

8.1 Summary

If the bushing is damaged, we recommend that it is returned to ABB for repairs and re-testing. Some parts that are damaged or lost during transportation or installation can be ordered from ABB.
9 Disposal and environmental information

9.1 Overview

This chapter specifies the materials used in the bushing. Comply with local environmental regulations on disposal of this product, the materials used are specified for this purpose.

9.2 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 striven 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.

Disposal of worn-out equipment

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

Much of the material, or the energy content in the material, can be recycled if it is sorted and cleaned. The quantity of material that can be recycled varies depending on the technical resources and capabilities in each country. Non-recyclable components should be sent to an approved environmental waste treatment plant for destruction or disposal.

The bushing has these parts and materials

- The insulator is made of silicone rubber on a tube of glass-fiber reinforced epoxy.
- The conductor is made of low-alloy
- The bushing is filled with insulating silicone gel.
- The condenser core is made of paper, 1 % aluminum foil (by weight), 2 g of carbon and 1 g of lead. There are also small quantities of rubber bonded cork, rubber seals, braided copper wire (tinned), braided copper strap, and silver glue.
- The flanges are made of aluminum alloy.
- The top housing, top end nut, test tap and flexible connection are made of aluminum alloys.
- The test tap has a body in epoxy, cover in aluminum, cable and contacts in brass.
- The 20 kV voltage tap option the flange is filled with approximately 2 dl silicone gel.
- Outer terminals of copper, brass or low-alloy aluminum can be plated with silver, tin, gold or nickel. The thickness of the plating is up to 20 μm.
- The fasteners are made of stainless steel.

Electronics

Electronics equipment should be sent to an approved recycling plant, or sorted into different component materials for correct processing.
Metals

Metals should be sorted according to type and surface coating, and sent to an approved recycling plant. After the removal of paint or other surface coatings, 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.

The recycling of precious metals is particularly important. Metals such as copper and silver are expensive, and are only present in small quantities in the earth's crust. Copper is primarily used in current conductors, contacts, and cables. Some contacts are silver plated. Fumes from some metals can cause environmental damage, this applies to 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 plant. The energy content in thermoplastics and thermosetting plastics can often be recovered through combustion at a plant built for the purpose. Thermoplastics can usually be melted down and reused without significant loss of quality. Composites can be fractioned and used as filling materials in other materials, or be disposed of.

Oils and greases

Before disposal of the bushing, oil, grease, and similar products must be removed and sent to an approved environmental waste treatment plant or recycling plant. 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. As an alternative, the energy content in oil can be recovered through combustion at a plant designed for the purpose.

Rubber

Send rubber to an approved environmental waste treatment plant, either for disposal or reuse for different purposes.

Rubber is used in seals and gaskets.

Other materials

Sort other materials and send them to an approved environmental waste treatment plant.
10 References

10.1 Summary

- Markings: Conforming to IEC/IEEE.
- Bushing diagnostics and conditioning, 2750 515-142.
- Technical guide, 1ZSC000563-AAW.
- Test adapter, Technical guide, 1ZSC000563-ACS.
- Test adapter, Installation and maintenance guide, 1ZSC000563-ACD.
- High-voltage test techniques, IEC 60060.
- Selection and dimensioning of high-voltage insulators for use in a polluted environment, IEC 60815.