Transformer bushing, type GGF 200/600
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 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>SF₆ gas</td>
<td>SF₆ gas must be recycled and never released into the atmosphere.</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>
2 Product description

2.1 Design

Overview

The GGF design combines the robustness of a conventional condenser core, with an SF$_6$ gas-filled cooling section, separated from the core by a rigid epoxy barrier. The thermal stability, and the cooling design relies on the thermal properties of the SF$_6$ gas.

General schematics

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Outer terminal</td>
</tr>
<tr>
<td>2</td>
<td>Outer silicone rubber insulator</td>
</tr>
<tr>
<td>3</td>
<td>Oil-filling valve</td>
</tr>
<tr>
<td>4</td>
<td>Mounting flange</td>
</tr>
<tr>
<td>5</td>
<td>Oil hood</td>
</tr>
<tr>
<td>6</td>
<td>Bottom contact</td>
</tr>
<tr>
<td>7</td>
<td>Condenser core</td>
</tr>
<tr>
<td>8</td>
<td>Test tap</td>
</tr>
<tr>
<td>9</td>
<td>Density guard</td>
</tr>
<tr>
<td>10</td>
<td>Bursting disc</td>
</tr>
</tbody>
</table>
Gas system and density monitoring

The operating pressure at standard atmospheric conditions is specified on the rating plate of the bushing. When filling the bushing with gas, the filling pressure is determined by referring to the table Gas-filling, temperature compensation, page 39.

The bushing has two density guards. If the SF₆ gas density decreases to less than the limit, then the density guards will operate an alarm.

The bushing can operate at the lower limit of gas density without restrictions, the limit is $P_{\text{abs}} 0.31 \text{ MPa} (+20 \degree \text{C}).$

By monitoring all gas density limits, counter measures can be taken to limit damage to the equipment.

⚠️ **CAUTION!**
Do not open the package of the density guard before installation. The density guard is a calibrated instrument, it must be handled with care and protected against mechanical damage.

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 bushing components]

1. Stud
2. Cover
3. Grounding spring
4. O-ring
Test adapter, 2769 522-C, optional equipment

The test adapter 2769 522-C is available for permanent connection to measuring circuits.

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>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Converter transformers and DC smoothing reactors.</td>
</tr>
<tr>
<td>Classification</td>
<td>Electrical bushing.</td>
</tr>
<tr>
<td></td>
<td>Inner part: Oil impregnated paper, capacitance graded, oil immersed.</td>
</tr>
<tr>
<td></td>
<td>Outer part: SF$_6$ gas-insulated.</td>
</tr>
<tr>
<td>Ambient temperature limits</td>
<td>$0 , ^\circ\text{C}$ to $+60 , ^\circ\text{C}$, for use in valve halls, or project specific.</td>
</tr>
<tr>
<td>Maximum altitude of site</td>
<td>$&lt;1000$ m (Bushings for other altitudes can be provided on request.)</td>
</tr>
<tr>
<td>Immersion medium, inner part</td>
<td>Transformer oil. Maximum daily mean oil temperature is current dependent and project specific.</td>
</tr>
<tr>
<td>Filling medium, outer part</td>
<td>SF$_6$ gas</td>
</tr>
<tr>
<td>Rated filling pressure of insulating medium:</td>
<td>$P_{\text{abs}}$ 370 kPa at $+20 , ^\circ\text{C}$</td>
</tr>
<tr>
<td>Test tap</td>
<td>According to IEEE potential tap type A. $U_r = \text{max } 600$ V.</td>
</tr>
<tr>
<td>Capacitance $C_2$ of test tap</td>
<td>$&lt;5000$ pF</td>
</tr>
<tr>
<td>Conductor</td>
<td>Center tube</td>
</tr>
<tr>
<td>Markings</td>
<td>Conforming to IEC/IEEE</td>
</tr>
</tbody>
</table>
List of bushings applicable to this installation guide

<table>
<thead>
<tr>
<th>Type</th>
<th>Article number</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGF 200</td>
<td>1ZSC002774-AAA</td>
</tr>
<tr>
<td>GGF 275</td>
<td>1ZSC026173-AAB</td>
</tr>
<tr>
<td>GGF 275E</td>
<td>1ZSC028041-AAB</td>
</tr>
<tr>
<td>GGF 400</td>
<td>1ZSC002774-AAB</td>
</tr>
<tr>
<td>GGF 400HC</td>
<td>1ZSC002774-AAD</td>
</tr>
<tr>
<td>GGF 600</td>
<td>1ZSC002774-AAC</td>
</tr>
</tbody>
</table>

2.2.2 Mechanical loading

Maximum permitted static load on the outer terminal

- $F_Z$ Maximum vertical cantilever load
- $F_Y$ Maximum axial static load
- $F_X$ Maximum horizontal cantilever load
- 4 Load applied at the midpoint
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.

3.2 Transportation

- The bushing must be transported in the transport box.
- The bushing must be transported in the horizontal position, with support over at least 75% of the length of the transport box.
- The bushing is delivered filled with nitrogen gas ($N_2$) at a pressure of $P_{abs}$ 125 kPa (+20 °C). This pressure must be maintained during transportation.
- Carefully inspect the bushing for damage after transportation.

CAUTION!

Do not stack more than 2 transport boxes.
3.3 Storage

Short term storage, less than 6 months

- 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 bushing dry, clean and protected against mechanical damage.
- The transport box must be stored in the horizontal position, with support over at least 75% of its length.
- The bushing is delivered filled with nitrogen gas (N\textsubscript{2}) at a pressure of P\textsubscript{abs} 125 kPa (+20 °C). This pressure must be maintained during storage.

⚠️ CAUTION!
Do not stack the transport boxes.

Long term storage, more than 6 months

- Keep the bushing dry, clean and protected against mechanical damage.
- Lift the bottom end of the transport box to an angle of at least 5°.
- The protection cap on the top of the bushing must be attached.
- The bushing is delivered filled with nitrogen gas (N\textsubscript{2}) at a pressure of P\textsubscript{abs} 125 kPa (+20 °C). This pressure must be maintained during storage.

The bushing is delivered from ABB in a transport box, and the bushing is held in place by support blocks and fiberboard in the box.

The transport box is marked with \textit{Top end}, this identifies the end to lower when the bushing is in storage.

⚠️ CAUTION!
Do not stack the transport boxes.
3.4 Lifting

3.4.1 Lifting the transport box

Overview

![Diagram showing lifting points and center of gravity]

<table>
<thead>
<tr>
<th>1</th>
<th>Center of gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Soft lifting slings</td>
</tr>
<tr>
<td>3</td>
<td>Forklift lifting points</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Weights</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transport box</td>
<td>Bushing</td>
</tr>
<tr>
<td>GGF 200</td>
<td>727 kg</td>
<td>2000 kg</td>
</tr>
<tr>
<td>GGF 275</td>
<td>805 kg</td>
<td>2150 kg</td>
</tr>
<tr>
<td>GGF 275E</td>
<td>805 kg</td>
<td>2545 kg</td>
</tr>
<tr>
<td>GGF 400</td>
<td>805 kg</td>
<td>2100 kg</td>
</tr>
<tr>
<td>GGF 400HC</td>
<td>805 kg</td>
<td>2250 kg</td>
</tr>
<tr>
<td>GGF 600</td>
<td>919 kg</td>
<td>2300 kg</td>
</tr>
</tbody>
</table>

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).

3. Make sure that the angle of the soft lifting sling is not more than 45°.

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.

4. Attach a soft lifting sling to the transport container and then to the crane hook.
5. Attach a soft lifting sling to the protection cap (1) and then to the crane hook.

6. Carefully lift the bushing.

7. Make sure that the support blocks are in the same positions as the support blocks in the transport box.

   **CAUTION!**
   Do not apply force to the silicone insulator, deformation will occur.

8. Lower the bushing onto the support blocks.

   End of instruction
### 4.1 Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Part number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft lifting slings</td>
<td>-</td>
<td>Refer to the data on mass as given by the rating plate on the bushing.</td>
</tr>
<tr>
<td>Pull-through cord</td>
<td>9760 669-A</td>
<td>For assembly and disassembly of the draw rod.</td>
</tr>
<tr>
<td>Torque wrench key for hex socket screws from 13 mm (M8) to 36 mm (M24).</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Torque wrench key for hex socket screws from 5 mm (M6) to 10 mm (M12).</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wrench for hex socket screws 13 mm and 24 mm.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Shackles</td>
<td>-</td>
<td>For hole Ø 20 mm, for connection of soft lifting slings to the bushing flange.</td>
</tr>
<tr>
<td>Lifting tackle</td>
<td>-</td>
<td>For installation of the bushing at a specific angle.</td>
</tr>
<tr>
<td>M6 x 40 bolts (2 pcs)</td>
<td>-</td>
<td>For removal of the sealing plate.</td>
</tr>
<tr>
<td>Lifting gear, flange</td>
<td>2013 254</td>
<td>For installation on the flange.</td>
</tr>
<tr>
<td>Lifting gear, top</td>
<td>2015 929</td>
<td>For tilted lifting of the bushing and retraction of the bottom contact.</td>
</tr>
<tr>
<td>Hydraulic jack (optional)</td>
<td>9769 897-A</td>
<td>12 ton, with accessories for assembly of the draw rod.</td>
</tr>
<tr>
<td>Bottom contact retractor</td>
<td>1ZSC002694-AAA</td>
<td>For installation of the bottom contact.</td>
</tr>
<tr>
<td>Box spanner</td>
<td>9760 669-B</td>
<td>For removal, and installation of the bottom contact.</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>Lubricates and protects metals against corrosion. Protects rubber. Does not react with transformer oil.</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>
<tr>
<td>Fomblin</td>
<td>Solvay</td>
<td>1171 4016-616 /OT20</td>
<td>For lubrication of bolts. For the sealing and lubrication of the sealing plate on the top end.</td>
</tr>
</tbody>
</table>
4.3 Preparations

4.3.1 Preparation of the bushing

Overview

This section describes the preparation procedure for installing the bushing on the transformer.

⚠️ **CAUTION!**

The condenser core cannot be exposed to open air for more than 2 hours.

- The bushing can be empty of oil for one week if it is installed on the transformer, or in the transport box.
- The bushing can be empty of oil for three weeks if:
  a) A vacuum is kept for a time-period of 24 hours, after the vacuum suction of the transformer is completed.
  b) 5 days pass before the transformer is energized.

Procedure

1. Remove the cover (1) and use suction to remove the oil from the transport container.

⚠️ **CAUTION!**

Do not cause damage to the condenser core. Use a soft hose instead of a pipe to remove the oil.

2. Make sure that oil is not leaking from the oil valve (3), or the oil plug (4).

   If leakage is found, replace the the oil valve (3), or O-ring in the oil plug (4).

   **NOTE!**

   If the flange does not have an oil plug, then examine both oil valves.

3. Put a container (>150 liter) under the oil plug (4).
4. Open the oil valve (3) and remove the oil plug (4) to drain the oil.

**DANGER!**
If oil spills, clean the area immediately. A wet surface is dangerous and can cause you to fall.

**CAUTION!**
Do not remove the upper threaded part from the oil valve.

**NOTE!**
If the flange does not have an oil plug, then open both oil valves.

5. Lift the top end of the bushing to let the oil drain fully.

**CAUTION!**
Make sure that the transport container does not hit the ground when you lift the top end.

6. Close the oil valve (3) and install the oil plug (4) again.
Use a new O-ring (1ZSC004442-CAB) when installing the oil plug again.

**CAUTION!**
After draining the oil, keep the bushing sealed in the transport container, to avoid exposure of the condenser core to ambient air.

**NOTE!**
If the flange does not have an oil plug, then close both oil valves.

7. Install the cover (1) again on the transport container.

8. Remove the M12 bolts (47) and washers. Then remove the protection cap (39).

**CAUTION!**
On spare transformers, install the protection cap again after installing the bushing.
9. Install two bolts (7) in the draw washer (6).

10. Turn the draw washer (6) counterclockwise to remove it.

11. Remove all M6 hex socket screws (9) from the outer sealing plate (10).

12. Install two M6 hex socket screws (9) in the outer sealing plate (10). Pull out the outer sealing plate (10).
13. Apply Fomblin to the bolts (16) and install the lifting gear (17).

**CAUTION!**
Be careful not to cause damage to the silver-plated top end (8).

14. Examine the pull-through cord for damage. If damage is found, replace it with a new pull-through cord.

15. Put the pull-through cord (12) through the box spanner (13), then connect it to the draw rod (14).

**NOTE!**
Do not to push the draw rod into the bushing without the pull-through cord attached.

16. Apply Fomblin to the thread on the pull-through cord (12) and connect it to the draw rod (14).

17. Pull out the draw rod (14) to access the key grip (33).

18. Tighten the pull-through cord (12) to the draw rod (14).

**Torque**

- 13. 49 Nm ±10%
- 14. 20 Nm
19. Hold the pull-through cord (12) in tension, and remove the nut (15). Move back the nut (15), the washers and the box spanner (13).

**NOTE!**
Keep the nut (15) and washers, they will be installed again.

20. Install the lifting tool (34) on the flange (41). Attach a soft lifting sling to the lifting tool (34).

21. Attach a soft lifting sling between the lifting gear (17) on the top of the bushing and the crane hook (20).

**DANGER!**
Use sufficiently long soft lifting slings to get an angle of ≥30°. Using shorter soft lifting slings can cause the bushing to fall, and cause injury or death to personnel.

**NOTE!**
Use the approximately same length for the soft lifting sling as the bushing is long.

22. Attach a lifting tackle (21) between the soft lifting sling to the flange and the crane hook.

**CAUTION!**
Make sure that the crane can lift the bushing.
23. Remove the transport container (22) from the bushing.

**CAUTION!**
The condenser core cannot be exposed to open air for more than 2 hours.

**CAUTION!**
Remove the transport container when nearby the transformer to avoid damage and dirt.

---

**4.3.2 Preparation of the bottom contact at the transformer factory**

**Procedure**

1. Make sure that all springs in the bottom contact are in position, and that the coils are arranged in alternating directions.

2. Remove the cover from the transformer turret.
3. Apply Vaseline to the contact surfaces of the winding cables. Install the winding cables with bolts and washers to the bottom contact.

![Diagram](image1)

**Torque**
M12: 68 Nm ±10%

4. Apply a thick layer of Vaseline to the silver-plated contact surface (23) and the chamfer (37).

![Diagram](image2)

End of instruction

### 4.3.3 Preparation of the bottom contact at site

**Procedure**

1. Remove the transport cover (27) from the transformer turret.

![Diagram](image3)
2. Remove the transport cover (27) from the lower draw rod (26).

3. Make sure that all springs in the bottom contact are in position, and that the coils are arranged in alternating directions.

4. Lower the draw rod through the bushing, and remove the protective bolt and washer (23) from the bottom end.

4.4 Installation on the transformer

4.4.1 Installation of the bushing on the transformer

Procedure

1. Lift the bushing.

2. Measure the angle of the transformer turret. Use the lifting tackle to adjust the bushing to the same angle.
3. Connect and tighten the upper and lower draw rods (26).

**NOTE!**
When installing at site, apply thread-locking fluid on the threads of the draw rod (26).

4. Hold the pull-through cord (12) in tension, and at the same time lower the bushing into position.

5. Install the nuts (40) and washers.

**Torque**
M24: 685 Nm ±10%
6. Pull the bottom contact into position with the bottom contact retractor (4).

7. Make sure that the bottom of the bottom contact (49) touches the housing (50).

8. Install the washers and nut (15).

   If the nut (15) cannot be turned smoothly, apply a generous quantity of Molykote 1000. Remove excess with a rag.

   **CAUTION!**
   Make sure that the washers are in the correct order.

---

43 Insulating washer
44 Plain washer large
45 Conical spring washer
46 Plain washer
15 Nut
9. Tighten the nut on the draw rod with a box spanner (13).

10. Remove the lifting tool (34).

11. Remove the lifting gear (17) and the pull-through cord.

End of instruction
4.4.2 Hydraulic tightening of the draw-rod nut

Procedure

1. Install the hydraulic jack (8).

2. Pull the draw rod with a force of 40 kN.

3. Tighten the nut (15) on the draw rod with your hand.

4. Remove the hydraulic jack (8).

End of instruction

4.4.3 Installation of the outer terminal

Procedure

1. Apply Fomblin to the O-rings (3 and 4), and install them on the sealing plate (14).
2. Apply Fomblin to the conical spring washers and plain washers (2), and the threads of the M6 hex socket screws (9).

3. Install the sealing plate (14) with the M6 hex socket screws (9), and washers (2).
   Tighten the M6 hex socket screws (9) in a crosswise sequence.

4. Install the draw washer (6):
   1. Apply Fomblin to the threads (20) of the draw washer (6).
   2. Put two M10 bolts (7) in the holes of the draw washer (6) and turn it clockwise.
   3. Remove the two M10 bolts (7).

   **NOTE!**
   Or use a lubricant with similar properties to Fomblin.
5. Apply a thick layer of Fomblin to the silver-plated contact surface (8) and the chamfer.

6. Make sure that all springs (21) in the outer terminal (24) are in position, and that the coils are arranged in alternating directions.

7. Apply a thin layer of Fomblin to the contact springs (21).

**NOTE!**
Or use a lubricant with equal properties to Fomblin.
8. Install the outer terminal (24).

9. Install the fasteners:
   1. Apply Fomblin to the conical spring-washers, plain washers and hex screws (25).
   2. Install the hex screws (25) with the washers. Tighten the hex screws (25) in a crosswise sequence.

   **NOTE!**
   Or use a lubricant with equal properties to Fomblin.

   Torque: 49 Nm ±5

---

**4.5 Installation of corona shields and external connections**

**Overview**

**CAUTION!**
Do not energize the bushing without the correct corona shield. This can lead to a flashover and serious damage to the equipment.

**NOTE!**
Clean the corona shield if it is dirty. Dirt or damages on the corona shield can lead to partial discharge in the air.

**NOTE!**
To prevent external heating of the bushing, the connection of the external bus must be assembled and connected according to the instructions from the supplier.

**NOTE!**
The corona shield is not included with the bushing, and must be ordered separately.
<table>
<thead>
<tr>
<th>Corona shield for</th>
<th>Article number</th>
<th>Alternative corona shield</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGF 200</td>
<td>1ZSC001635-AAF</td>
<td>1ZSC001635-AAE</td>
</tr>
<tr>
<td>GGF 275</td>
<td>1ZSC001635-AAF</td>
<td>Not available</td>
</tr>
<tr>
<td>GGF 275E</td>
<td>1ZSC001635-AAF</td>
<td>Not available</td>
</tr>
<tr>
<td>GGF 400</td>
<td>1ZSC001635-AAF</td>
<td>1ZSC001635-AAE</td>
</tr>
<tr>
<td>GGF 400HC</td>
<td>1ZSC001635-AAF</td>
<td>1ZSC001635-AAE</td>
</tr>
<tr>
<td>GGF 600</td>
<td>1ZSC001635-AAE</td>
<td>Not available</td>
</tr>
</tbody>
</table>

**Procedure**

1. Apply Fomblin to the contact surfaces.

2. Install the corona shield with M8x30 bolts, conical spring washers and washers (8 pcs).

   **CAUTION!**
   Use only stainless fasteners.

3. Tighten the bolts in a crosswise sequence.

   **Torque**
   24.5 Nm ±10%

4. Apply surface treatment on the external connection.

5. Install the external connection, refer to the instructions from the supplier.

End of instruction
4.6 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
4.7 Oil-filling

Overview

The bushing is filled with transformer oil at the same time as the transformer. They share the same oil conservator, and cannot be vacuum sucked or oil-filled individually. The following procedure describes what has to be done to correctly fill the bushing with transformer oil.

Procedure

1. Connect a transparent hose (1) and a pressure gauge to the valve (2).

   **CAUTION!**
   Make sure that the connections of the hose (1) are air tight.

2. Put the hose (1) as high as possible, at least above the highest point of the conservator. Then connect the hose (1) to the vacuum pump.

3. Start the vacuum pump to remove the air.

4. When the air is removed, open the valve (2).
5. Measure the pressure in the hose (1) from the bushing. Make sure that the pressure is below $p_{\text{abs}} \leq 30 \text{ Pa}$.

6. Maintain a vacuum for the specified time.

   **NOTE!**
   The time is specified in the documentation for the transformer.

7. Fill the transformer with oil.

   **NOTE!**
   It is important to increase the oil-filling pressure at the end of the filling process to approximately 0.18 Mpa, to ensure a complete filling of the bushing.

8. When the oil-level stops rising in the transparent hose (1), open the hose (1) to the atmosphere.

9. Monitor the oil-level until it stops decreasing.

10. Make sure the oil-level in the hose (1) is not lower than the height ($h$). Calculate the height ($h$) as follows:

    $$ h = L \sin(a) \text{ example; } h = 4000 \times \sin(20) $$

    | Type     | L (mm) |
    |----------|--------|
    | GGF 200  | 3000   |
    | GGF 275  | 3000   |
    | GGF 275E | 3700   |
    | GGF 400  | 3000   |
    | GGF 400HC| 3000   |
    | GGF 600  | 3000   |

11. Close the valve (2) on the flange.

---

### 4.8 Gas-filling

#### 4.8.1 Gas overview

**Overview**

**DANGER!**

$\text{SF}_6$ gas must be recycled and not released into the atmosphere.

**DANGER!**

Risk of asphyxiation!

$\text{SF}_6$ gas is denser than air, it is invisible and does not smell. If gas is released it will settle in low areas, and there is a significant risk of asphyxiation and death if entering the area.
DANGER!
Before starting the gas-filling procedure, go to a protected area at safe distance from the bushing. An explosion can cause death or injury to personnel and/or damage equipment.

DANGER!
Lifting/moving a pressurized bushing is not allowed. Reduce the pressure of the bushing to the transport pressure before lifting/moving. An explosion can cause death or injury to personnel and/or cause damage to the equipment.

CAUTION!
Handle the density guard with care. It is a calibrated instrument that must be protected against any mechanical damage. Do not remove the package of the density guard before installation.

CAUTION!
Do not remove the protective cover from the bursting disc, this can cause damage to the bursting disc.

NOTE!
The permitted quality of the SF₆ gas is specified in the standard IEC 60376.

NOTE!
The bushings operational pressure is $P_{\text{abs}}$ 370 kPa at $+20 \, ^\circ\text{C}$. The bushings are tested for maximum operating pressure ($MOP_{\text{abs}}$) 440 kPa at high ambient temperatures.

NOTE!
The bushing has a bursting disc, it is made for a maximum operating pressure of ($MOP_{\text{abs}}$ 440 kPa).

The purpose of the SF₆ gas is to electrically insulate the internals of the bushing, but also to cool the tubular conductor. Its efficiency depends on the density of the gas.

When the bushing is delivered from the manufacturer it is filled with N₂ gas, at a transport pressure of $P_{\text{abs}}$ 125 kPa.

The bushing has two density guards. In the event of a low level of SF₆ gas density in the bushing, an alarm operates.
Description of SF6 gas

Sulfur-hexafluoride (SF₆) is a synthetic gas, it is colorless, it does not smell and does not burn. The gas is chemically very stable, and it does not react with any other substance at room temperature. The stability of the gas is the reason for its use in electrical equipment, because it provides very high electrical insulation. These properties of SF₆ gas makes possible the construction of devices and equipment with small dimensions, using less material, that are safe and have long service lives. For electrical equipment, the SF₆ gas is only used in closed and sealed systems, e.g. as insulation gas in substations.

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Sulfur-hexafluoride</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical properties</td>
<td>Colorless, odorless, non-toxic, non-flammable and chemically inert.</td>
</tr>
<tr>
<td>Electrical properties</td>
<td>High dielectric strength.</td>
</tr>
<tr>
<td>Climate affecting CO₂ equivalent</td>
<td>22800</td>
</tr>
<tr>
<td>Lifetime in the atmosphere</td>
<td>3200 years</td>
</tr>
</tbody>
</table>

Gas-filling, temperature compensation

The correct gas pressure in the bushing depends on the ambient temperature. The gas-filling procedure cools the bushing, and it is necessary to wait 24 hours before the gas pressure can be reliably measured. After 24 hours from gas-filling, the gas pressure in the bushing must correspond to the ambient temperature, refer to the table.

<table>
<thead>
<tr>
<th>Ambient temperature (°C)</th>
<th>-30</th>
<th>-20</th>
<th>-10</th>
<th>0</th>
<th>+10</th>
<th>+20</th>
<th>+30</th>
<th>+40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (P_{abs} kPa)</td>
<td>300</td>
<td>320</td>
<td>330</td>
<td>340</td>
<td>360</td>
<td>370</td>
<td>380</td>
<td>400</td>
</tr>
</tbody>
</table>
Several types of density switches are available with different triggering conditions. The standard unit has three switches at three different gas densities, and gives the highest versatility when analyzing the switch settings in a logical way.

**Alarm level 1 (D1: $P_{\text{abs}}$ 0.35 MPa)**  
Switch number D1 is activated, circuit 11–14 is opened and 11–12 is closed. This indicates gas density lower than level 1.

**Alarm level 2 (D2: $P_{\text{abs}}$ 0.33 MPa)**  
Switch number D2 is activated, circuit 21–24 is opened and 21–22 is closed. This indicates gas density lower than level 2.

**Alarm level 3 (D3: $P_{\text{abs}}$ 0.31 MPa)**  
Switch number D3 is activated, circuit 31–34 is opened and 31–32 is closed. This indicates gas density lower than level 3.
Electrical connections analogue output from hybrid density guards

The hybrid density guards have switching contacts and an analogue output with current loop. The connections are as shown.

From the 6.5–20 mA output the absolute pressure at +20 °C can be calculated by

\[ P_{\text{abs}} = 63.03 \cdot I - 414.19 \text{ [kPa]} \]

\( I \) in (mA)

And the density from

\[ \rho = (\sqrt{4.651 \cdot (I - 6.005) - 2.185 - 0.44})^2 \]

\( I \) in (mA)
4.8.3 Gas-filling

Procedure

1. Connect the gas-filling equipment to one of the gas valves:
   1. Push the nozzle of the gas connection into the gas valve.
   2. Turn the union nut.

   **NOTE!**
   A density guard must be installed, and connected to the adjacent gas valve.

2. Install a density guard (19) on the free gas valve and connect it to the input of the alarm system.

   **CAUTION!**
   Do not turn the density guard after installation.
   Turning the density guard will cause damage to the capillary tubes inside it. All warranties will be invalidated.

3. Remove all of the N₂ gas to a vacuum of Pₐ₂₅₀ Pa.

4. Fill the bushing with SF₆ gas.

5. When the gauge of the gas-filling system indicates a pressure of about Pₐ₂₂₅₀ kPa (Pₑ1₅₀ kPa) reduce the gas-filling speed. Pay attention to the changing status in the alarm system.

   **NOTE!**
   At about Pₐ₂₃₂₀ kPa (Pₑ2₂₂₀ kPa) switch D₂ should change status.
   At about Pₐ₂₆₇₀ kPa (Pₑ5₇₀ kPa) switch D₂ should change status.

6. When switch D₂ changes status at about Pₐ₂₃₃₀ kPa (Pₑ2₃₀ kPa), temporarily stop the gas-filling.
7. Stop gas-filling when the pressure is $P_{\text{abs}}$ 370 kPa ($P_e$ 270 kPa) at the ambient temperature (+20 °C). If the ambient temperature differs from +20 °C, then refer to the table in *Gas-filling, temperature compensation*, page 39.

<table>
<thead>
<tr>
<th>Type</th>
<th>Approximate amount of SF$_6$ gas</th>
<th>CO$_2$ gas equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGF 200</td>
<td>13 kg</td>
<td>297 tonne</td>
</tr>
<tr>
<td>GGF 275</td>
<td>17 kg</td>
<td>388 tonne</td>
</tr>
<tr>
<td>GGF 275E</td>
<td>17 kg</td>
<td>388 tonne</td>
</tr>
<tr>
<td>GGF 400</td>
<td>15 kg</td>
<td>342 tonne</td>
</tr>
<tr>
<td>GGF 400HC</td>
<td>15 kg</td>
<td>342 tonne</td>
</tr>
<tr>
<td>GGF 600</td>
<td>19 kg</td>
<td>433 tonne</td>
</tr>
</tbody>
</table>

**NOTE!**
The pressure levels apply when the complete gas volume has reached the current ambient temperature.

**NOTE!**
It is necessary to wait 24 hours after gas-filling, before a correct reading can be made.

8. Make sure that all three switches in the active unit indicates nominal pressure.

9. Remove the gas-filling equipment.

10. Make sure that the gas valve and the density guard are clean.

11. Install the density guard (48).

**CAUTION!**
Do not turn the density guard after installation.

Turning the density guard will cause damage to the capillary tubes inside it.
All warranties will be invalidated.

**NOTE!**
If the density guard is prewired into the control system, it should give indication in all its three stages if the bushing is correctly filled with gas.

**End of instruction**
4.9 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Flashover distance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGF 200</td>
<td>3600</td>
</tr>
<tr>
<td>GGF 275</td>
<td>4350</td>
</tr>
<tr>
<td>GGF 275E</td>
<td>4750</td>
</tr>
<tr>
<td>GGF 400</td>
<td>4350</td>
</tr>
<tr>
<td>GGF 400HC</td>
<td>4350</td>
</tr>
<tr>
<td>GGF 600</td>
<td>5800</td>
</tr>
</tbody>
</table>
5 Commissioning

5.1 Waiting time before energization

General requirements for the bushing

The bushing can be empty of oil for short periods of time if it is protected from the atmosphere:

- If the bushing has been empty of oil for less than one week, then the waiting time before energization is fulfilled during the oil processing of the transformer.
- If the bushing has been empty of oil for one to three weeks:
    a) A vacuum is kept for a time-period of 24 hours, after the vacuum suction of the transformer is completed.
    b) 5 days pass before the transformer is energized.

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>
</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 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.

#### 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>0.80</td>
</tr>
<tr>
<td>3-7</td>
<td>0.85</td>
</tr>
<tr>
<td>8-12</td>
<td>0.90</td>
</tr>
<tr>
<td>13-17</td>
<td>0.95</td>
</tr>
<tr>
<td>18-22</td>
<td>1.00</td>
</tr>
<tr>
<td>23-27</td>
<td>1.05</td>
</tr>
<tr>
<td>28-32</td>
<td>1.10</td>
</tr>
<tr>
<td>33-37</td>
<td>1.15</td>
</tr>
<tr>
<td>38-42</td>
<td>1.20</td>
</tr>
<tr>
<td>43-47</td>
<td>1.25</td>
</tr>
<tr>
<td>48-52</td>
<td>1.30</td>
</tr>
<tr>
<td>53-57</td>
<td>1.34</td>
</tr>
<tr>
<td>57-62</td>
<td>1.35</td>
</tr>
<tr>
<td>63-67</td>
<td>1.35</td>
</tr>
<tr>
<td>68-72</td>
<td>1.30</td>
</tr>
<tr>
<td>73-77</td>
<td>1.25</td>
</tr>
<tr>
<td>78-82</td>
<td>1.20</td>
</tr>
<tr>
<td>83-87</td>
<td>1.10</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>1ZSC004579-AAA</td>
</tr>
<tr>
<td>O-ring</td>
<td>1ZSC004442-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 (3).

5. Measure the capacitance ($C_1$) between the outer terminal and the stud (1).
   
   **NOTE!**
   Refer to the rating plate for the nominal capacitance ($C_1$).

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

7. 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.

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

End of instruction
Overview

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.

Do the measurement of through-resistance before connecting any of the external circuits.

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 Removal of the SF6 gas

Overview

During transport the bushing must be filled with nitrogen ($N_2$) at a transport pressure of $P_{\text{abs}}$ 125 kPa. The bushing must not contain SF$_6$ gas.

**DANGER!**

SF$_6$ gas must be recycled and not released into the atmosphere.

**DANGER!**

Risk of asphyxiation!

SF$_6$ gas is more dense than air, it is invisible and does not smell. If gas is released it will settle in low areas, and there is a significant risk of asphyxiation and death if entering the area.

**DANGER!**

Before starting the gas-filling procedure, go to a protected area and a safe distance from the bushing. An explosion can cause death or injury to personnel and/or damage equipment.

Procedure

1. Connect the SF$_6$ gas service unit.

2. Remove all of the SF$_6$ gas to a vacuum of $P_{\text{abs}}$ 200 Pa.

   **NOTE!**

   The SF$_6$ gas must be recovered for reuse or destruction.

   **NOTE!**

   The permitted quality of the SF$_6$ gas is specified in the standard IEC 60376.

3. Fill the bushing with dry nitrogen ($N_2$) to a pressure of $P_{\text{abs}}$ 100 kPa.

4. Remove again all the nitrogen ($N_2$) to a vacuum of $P_{\text{abs}}$ 200 Pa.

5. Fill the bushing again with dry nitrogen ($N_2$) to a transport pressure of $P_{\text{abs}}$ 125 kPa.

End of instruction
7.2 Removal of the bottom contact

Overview

⚠️ CAUTION!
Empty the bushing from oil and gas before removing the bushing from the transformer.

⚠️ CAUTION!
The condenser core may not be exposed to open air for more than 4 hours.

Procedure

1. Remove the external connections and the corona shield.

2. Remove the density guards.

3. Do gas treatment. Fill the bushing with nitrogen to $P_{\text{abs}} = 125$ kPa.

4. Remove the hex socket screws (25), and washers, and remove the outer terminal (24).

5. Install two bolts (7) in the draw washer (6).

6. Turn the draw washer (6) counterclockwise to remove it.
7. Remove the M6 hex socket screws (9), and the washers (2).

8. Install two two M6 hex socket screws (9) in the outer sealing plate (10), and pull it out.

   **CAUTION!**
   Do not remove the inner sealing plate.

9. Apply Fomblin to the bolts (16) and install the lifting gear (17).

   **CAUTION!**
   Be careful not to cause damage to the silver-plated top end (8).

   
   **Torque**
   49 Nm ±10%

10. Examine the pull-through cord for damage. If damage is found, then replace it with a new pull-through cord.
11. Put the pull-through cord (12) through the box spanner (13) and install it in the draw rod (14).

12. Hold the pull-through cord (12) in tension, while removing the nut (15). Move back the box spanner (13), the nut (15) and the washers.

**NOTE!**
Keep the nut and washers, they will be installed again.

13. Make sure that the bottom contact is loose from the bushing.

End of instruction
7.3 Removal of the bushing from the transformer

Procedure

1. Install the lifting tool (34) on the flange (41). Attach a soft lifting sling (18) to the lifting tool (34).

2. Attach a soft lifting sling between the lifting gear (17) on the top of the bushing and the crane hook (20).

   **DANGER!**
   Use sufficiently long soft lifting slings to achieve an angle of ≥30°. Using shorter soft lifting slings can cause the bushing to fall, and cause injury or death to personnel.

   **NOTE!**
   Use the approximately same length for the soft lifting sling as the bushing is long.

3. Attach a tackle (21) between the soft lifting sling to the flange and the crane hook (20).

4. Remove bolts (3) and washers.
5. Hold the pull-through cord (12) in tension, while lifting the bushing out of the transformer.

**CAUTION!**
The nut (15) must be completely removed from the draw rod before lifting the bushing.

6. Remove the upper draw rod (14) from the lower draw rod (26).

**NOTE!**
There is a key-grip on the lower draw rod (26).
7.4 Preparations for transportartion

Procedure

1. Make sure that the washers are in the correct order.

2. Pull up the draw rod with the pull-through cord (12). Tighten the nut (15) on the draw rod with the box spanner (13).

3. Lower the bushing onto the support blocks.

CAUTION! Make sure that the ground is flat, and that the support blocks are in the same positions as they were in the transport box.
4. Install the draw rod (26) to the transportation cover (27), and put the transportation cover (27) on the transformer.

5. Apply Fomblin to the bolts, and install the bolts in the transportation cover (27).

6. Apply Fomblin to the bolts, and install the transport container (22).

   **CAUTION!**
   The condenser core may not be exposed to open air for more than 4 hours.

   **Torque**
   M24x90
   396 Nm ±10%

7. Remove the lifting gear (17), the box spanner (13) and the pull-through cord (12).

   **CAUTION!**
   Be careful not to cause damage the silver-plated top end (8).
8. Apply Fomblin to the hex socket screws (9) and install the sealing plate (14).

9. Tighten the hex socket screws (9) in a crosswise sequence.

   Torque
   M6: 10 Nm ±10%

10. Install the draw washer (6):
    1. Apply Fomblin to the threads (20) of the draw washer (6).
    2. Put two M10 bolts (7) in the holes of the draw washer (6) and turn it clockwise.
    3. Remove the two M10 bolts (7).

   NOTE!
   Or use lubricant with similar properties to Fomblin.

11. Apply Fomblin to the bolts (47) and washers. Install the protection cap (39).

   Torque
   M12: 84 Nm ±10%

End of instruction
7.5 Oil-filling of the transport container

Overview

Procedure for bushings without return valve

1. Connect a transparent hose (48) to the oil-filling valve and then to a vacuum pump.

2. Open the oil-filling valve (49) and start the vacuum pump.

3. Remove the cover (1) and fill the transport container with oil.

4. When oil starts to flow in the transparent hose (48):
   1. Stop the oil-filling and the vacuum pump.
   2. Close the oil-filling valve (49).
5. Make sure that the oil-level (L) is correct, refer to the table.

<table>
<thead>
<tr>
<th>Type</th>
<th>Oil level from top</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGF 200</td>
<td>125 mm</td>
</tr>
<tr>
<td>GGF 275</td>
<td>125 mm</td>
</tr>
<tr>
<td>GGF 275E</td>
<td>125 mm</td>
</tr>
<tr>
<td>GGF 400</td>
<td>125 mm</td>
</tr>
<tr>
<td>GGF 400HC</td>
<td>125 mm</td>
</tr>
<tr>
<td>GGF 600</td>
<td>125 mm</td>
</tr>
</tbody>
</table>

**NOTE!**
Measure the oil level and adjust the level according to the table.

6. Install the cover (1).

**End of instruction**

7.6 Re-packing of the bushing

**Overview**

**DANGER!**
Risk of asphyxiation!

Do not transport the bushing when it is filled with SF$_6$ gas.
Procedure

1. Make sure that the SF₆ gas is removed from the bushing, and that the bushing is filled with nitrogen gas (N₂) at a pressure of Pₐₚₛ 125 kPa (+20 °C).

   CAUTION!
   Do not transport the bushing when it is filled with SF₆ gas.

   CAUTION!
   SF₆ gas must be recycled and not released into the atmosphere.

2. Lift the bushing. Refer to _Lifting the bushing out of the transport box, page 14_.

3. Lower the bushing into the transport box.

   CAUTION!
   Do not apply force to the polymeric insulator, deformation will occur.

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

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

4. 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.

5. Close the transport box.

   NOTE!
   Refer to _Lifting the transport box, page 13_ and _Transportation, page 11_.

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
- Conductor made of copper.
- Terminals made of copper, or low-alloy aluminum that is sometimes plated with silver.
- Transformer oil, refer to IEC 60296, class 2.
- Condenser core is made of paper and 1% aluminum foil, impregnated with transformer oil.
- Test tap is made of aluminum alloys.
- Flanges, cover and gas-filling valves are made of aluminum.
- Oil-filling valves are made of stainless steel and plastic.
- The insulator is made of silicone rubber on a tube of glass-fiber reinforced epoxy.
- Bushing is filled with sulfur hexafluoride (SF₆).

Gas
The SF₆ gas must be removed before disposal of the bushing. All handling of SF₆ gas must be done with care and according to the applicable regulations, to make sure that gas does not leak into the environment. Used gas can be:
- Regenerated on-site, and reused in other equipment.
- Sent to the gas supplier for regeneration.
- Sent for destruction at a special waste treatment plant.

If the bushing is filled with mixed gas, the SF₆ gas can be separated from the mixture for regeneration. As an alternative, 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 disposal of a bushing.

⚠️ DANGER!
SF₆ gas must be recycled and not released into the atmosphere.
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 Reference

10.1 Summary

- Markings: Conforming to IEC/IEEE.
- Bushing diagnostics and conditioning, 2750 515-142.
- The quality of the SF₆ gas must comply with standard IEC 60376.
- Transformer oil, IEC 60296, class 2.