Gas-insulated wall bushing, type GGFL
400/420/600/800
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.</td>
</tr>
<tr>
<td></td>
<td>If work must be done close to live plant components, make sure that</td>
</tr>
<tr>
<td></td>
<td>the safety distance is in compliance with the applicable safety</td>
</tr>
<tr>
<td></td>
<td>regulations.</td>
</tr>
<tr>
<td>Working on ladders and platforms.</td>
<td>Work must be done in accordance with the applicable safety</td>
</tr>
<tr>
<td></td>
<td>regulations.</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>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>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</td>
</tr>
<tr>
<td></td>
<td>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 GGFL bushing is a gas-insulated bushing made for use in building walls, such as HVDC valve-halls. The main insulation is compressed SF$_6$ gas. The bushing has an aluminum intermediate flange with two insulators, one for each side of the wall.

General schematics

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Outer terminal (outdoor/A-side)</td>
</tr>
<tr>
<td>2</td>
<td>Corona shield</td>
</tr>
<tr>
<td>3</td>
<td>Insulator (outdoor/A-side)</td>
</tr>
<tr>
<td>4</td>
<td>Insulator (indoor/B-side)</td>
</tr>
<tr>
<td>5</td>
<td>Intermediate flange</td>
</tr>
<tr>
<td>6</td>
<td>Outer terminal (indoor/B-side)</td>
</tr>
<tr>
<td>7</td>
<td>Density guard</td>
</tr>
<tr>
<td>8</td>
<td>Rating plate</td>
</tr>
<tr>
<td>9</td>
<td>Bursting disc</td>
</tr>
<tr>
<td>10</td>
<td>Flexible cable for grounding (not supplied by ABB Components)</td>
</tr>
</tbody>
</table>
2.2 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 29.

The bushing has two density guards. If the SF$_6$ 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 MPa (+20 °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.

2.3 Technical specifications

2.3.1 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>Application:</th>
<th>Wall bushing for use in valve halls or equivalent environment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification:</td>
<td>SF$_6$ gas-insulated bushing.</td>
</tr>
<tr>
<td>Ambient temperature limits:</td>
<td>+60 °C to -20 °C.</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>Level of rain and humidity:</td>
<td>According to IEC 60060-1 and IEEE.</td>
</tr>
<tr>
<td>Pollution level:</td>
<td>According to specific creepage distance and IEC 60815.</td>
</tr>
<tr>
<td>Type of insulating medium:</td>
<td>SF$_6$ gas.</td>
</tr>
<tr>
<td>Rated filling pressure of insulating medium:</td>
<td>$P_{\text{abs}}$ 570 kPa at +20 °C.</td>
</tr>
<tr>
<td>Markings:</td>
<td>Conforming to IEC/IEEE</td>
</tr>
</tbody>
</table>

The product series has these models:

<table>
<thead>
<tr>
<th>Type</th>
<th>Article number</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGFL 400</td>
<td>1ZSC0002776-AAA</td>
</tr>
<tr>
<td>GGFL 420</td>
<td>1ZSC0002640-AAB</td>
</tr>
<tr>
<td>GGFL 600</td>
<td>1ZSC0003517-AAA</td>
</tr>
<tr>
<td>GGFL 800</td>
<td>1ZSC0002777-AAA</td>
</tr>
</tbody>
</table>
### 2.3.2 Mechanical loading

Maximum permitted static load on the outer terminals

<table>
<thead>
<tr>
<th>Type</th>
<th>Maximum service load $F_X$ (N)</th>
<th>Maximum service load $F_Y$ (N)</th>
<th>Maximum service load $F_Z$ (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGFL 400</td>
<td>2500</td>
<td>1300</td>
<td>1300</td>
</tr>
<tr>
<td>GGFL 420</td>
<td>2500</td>
<td>1300</td>
<td>1300</td>
</tr>
<tr>
<td>GGFL 600</td>
<td>2500</td>
<td>1300</td>
<td>1300</td>
</tr>
<tr>
<td>GGFL 800</td>
<td>2500</td>
<td>1300</td>
<td>1300</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.

3.2 Transportation

- The bushing must be transported in the transport box.
- The bushing must be transported in the horizontal position.
- 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.

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 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 storage.

Long term storage, more than 6 months

- Keep the bushing dry, clean and protected against mechanical damage.
- 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 storage.

The transport box is marked with Top end, this identifies the end to when the bushing is in storage.

CAUTION!

Do not store the bushing in an environment with high humidity or varying temperatures. Store it indoors with a controlled temperature and non-condensing humidity.
3.4 Lifting

3.4.1 Lifting the transport box

Overview

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 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.

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 center housing and then to the crane hook.
5. Attach a soft lifting sling to the outer terminal (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.

9. If there is a Cargolog and a fastening plate then remove them.

   End of instruction
4 Installation

4.1 Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft lifting slings</td>
<td>Refer to Preparations, page 16.</td>
</tr>
<tr>
<td>Counter weight</td>
<td>Maximum 250 kg.</td>
</tr>
<tr>
<td>Fixation device</td>
<td>For the counter weight.</td>
</tr>
<tr>
<td>Cardboard</td>
<td>For protecting the insulator when installing the bushing into the wall.</td>
</tr>
<tr>
<td>Lifting tackle</td>
<td>For installation of the bushing at a specific angle.</td>
</tr>
<tr>
<td>Thermometer</td>
<td>For measuring the ambient temperature when filling with gas.</td>
</tr>
<tr>
<td>Precision manometer</td>
<td>100–600 kPa</td>
</tr>
<tr>
<td>Torque wrench</td>
<td>For 13 mm (M8) to 36 mm (M24).</td>
</tr>
<tr>
<td>Torque wrench</td>
<td>For 5 mm (M6) to 10 mm (M12).</td>
</tr>
<tr>
<td>Wrenches</td>
<td>For hex socket screws 13 mm and 24 mm.</td>
</tr>
<tr>
<td>Gas filling equipment</td>
<td>For filling the bushing with gas.</td>
</tr>
<tr>
<td>Vacuum pump</td>
<td>For vacuum treatment of the bushing.</td>
</tr>
</tbody>
</table>

NOTE!
If not specifically stated, none of the tools are provided by ABB.

4.2 Consumables

<table>
<thead>
<tr>
<th>Item</th>
<th>Brand</th>
<th>Part number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobilgrease 28</td>
<td>MOBIL</td>
<td>1171 4014-407</td>
<td>Lubricates and protects metals against corrosion. Protects rubber.</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

Overview

This section describes the preparation procedure for installing the wall bushing.

**DANGER!**
Risk of explosion!

Do not fill the bushing to operational pressure before it is installed in the wall. The bushing can explode if damage is caused to the insulator, when the pressure is higher than transport pressure.

**NOTE!**
If surrounding space is limited when installing the bushing in the wall then a different installation sequence can be used. For example if the transportation supports are difficult to remove.

**NOTE!**
If measurement of capacitance is necessary, first lift the bushing with soft lifting slings to a height of more than 3 m over the ground.

Measured values from a bushing that is installed in a wall, cannot be compared to the values provided by ABB.

**Length and weight**

<table>
<thead>
<tr>
<th>Bushing</th>
<th>GGFL 400</th>
<th>GGFL 420</th>
<th>GGFL 600</th>
<th>GGFL 800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft lifting sling 5</td>
<td>5 m</td>
<td>4 m</td>
<td>5 m</td>
<td>7 m</td>
</tr>
<tr>
<td>Soft lifting sling 4</td>
<td>7 m</td>
<td>6 m</td>
<td>8 m</td>
<td>11 m</td>
</tr>
<tr>
<td>Length of bushing</td>
<td>11.5 m</td>
<td>9.4 m</td>
<td>14.4 m</td>
<td>18.8 m</td>
</tr>
<tr>
<td>Weight</td>
<td>1744 kg</td>
<td>1465 kg</td>
<td>2335 kg</td>
<td>3841 kg</td>
</tr>
</tbody>
</table>
### Procedure

1. Make sure that the bushing is not damaged and that all items have been delivered, refer to the packing list.

2. Attach a short soft lifting sling (5) to the center housing and to the lifting device (3).

   **NOTE!** Instead of using a long soft lifting sling (4) on the outer terminal, it is possible to use two short soft lifting slings with a lifting tackle between them.

3. Attach a long soft lifting sling (4) to the outer terminal (1) and to the lifting device (3).

   **CAUTION!** Be careful not to cause damage to the silver-plated contact surface on the outer terminal.

   **CAUTION!** Make sure that the angle of the long soft lifting sling is more than 30°, a smaller angle can cause damage.

4. Carefully lift the bushing from the ground and remove the support blocks.

5. If the bushing is not stable in the horizontal position, then attach a counter weight to the outer terminal or use a lifting tackle to align the bushing.

   **CAUTION!** Do not use a counter weight that is heavier than 250 kg, because a heavier counter weight can cause damage.

6. Put thick cardboard (6) around the indoor/B-side insulator.
7. Lift the bushing to its position in front of the wall mount.

End of instruction

4.4 Installation of the bushing in the wall

Procedure

1. Make sure that the bushing aligns with the wall mount.

2. Carefully insert the bushing into the wall mount.

   **CAUTION!**
   Make sure that the cardboard (6) does not fall off the insulator. The insulator is easily damaged during the installation of the bushing in the wall.

   **NOTE!**
   The bursting disc must be placed downwards.

3. Install the bolts (1). Tighten the bolts in a crosswise sequence.

   **NOTE!**
   GGFL 400 installs with an angle. Therefore install the bolts at the lower edge of the flange first.

   **Torque**
   M20: 396 Nm ±10%

4. Remove the cardboard (6) from the insulator.

5. Remove the soft lifting slings.
6. Clean the surface (4) of center housing.

CAUTION!
Contaminants that fall into the housing will cause damage to the bushing when it is energized.

7. Depress the ball in the gas valve (3) on the center housing, to remove the pressure in the bushing.

CAUTION!
Only depress the ball in the gas valve if the bushing is filled with nitrogen (N₂). The bushing must not contain SF₆ gas.

8. Remove the transportation supports (5).

CAUTION!
Install the gas valve and the bursting disc after maximum three hours. Moisture that enters the center housing can cause damage to the bushing.

NOTE!
Keep the transportation supports, they must be installed again when the bushing is removed from the wall.
9. Remove the transportation support (6).

**NOTE!**
Keep the transportation support, the bolts and the O-ring, they must be installed again when the bushing is removed from the wall.

10. Examine the O-rings on the gas valve. Then make sure that the orifice is clean.
    Apply a thin layer of Fomblin to the O-rings.
    Replace defective O-rings.

11. Install the three gas valves (7).

    **CAUTION!**
    Incorrectly installed O-rings may cause damage to the bushing when it is energized.

    **Torque**
    M8 A4-80: 22 Nm ±5%

12. Install two density guards (9) on the gas valves.

    **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.
13. Examine the O-rings (12) on the bursting disc (10). Then make sure that the O-ring grooves (11) and sealing surfaces are clean. Replace defective O-rings.

**NOTE!**
The bursting disc is assembled and tested by ABB components before delivery, do not disassemble the bursting disc.

14. Apply a thin layer of Fomblin to the O-rings (12) and install the bursting disc (10).

**CAUTION!**
Incorrectly installed O-rings may cause damage to the bushing when it is energized.

**Torque**
M12 A4-80: 76 Nm ±5%

15. Remove the protective cap from the gas valve (3).

16. Attatch a hose to the gas valve (3). Then to the vacuum equipment.

**NOTE!**
Attach hose by pressing the nozzle of the gas connection into the gas valve and lock by turning the union nut.

17. Start the vacuum pump. When the pressure has decreased to $p_{abs}$ 200 Pa, remove the hose.

End of instruction
4.5 Installation of the outer terminals

Overview

NOTE!
Do this procedure only if the outer terminals have been removed. The outer terminals are installed from factory.

1. Clean the bushing cap (6).

CAUTION!
Do not brush the contact surfaces of the bushing cap and the terminal.
2. Apply Fomblin to the bolts (2).

Install the terminal (1) with the O-ring (5), the bolts (2), the conical spring washer (4), and the washer (3).

**NOTE!**
Do not use contact paste or grease between the terminal and the cap.

3. Tighten the bolts (2) in a crosswise sequence in stages.

![Torque](40 Nm)

---

4.6 Installation of the corona shields and the external connections

**Overview**

**DANGER!**
Do not go into the corona shield during installation. Use an extender for installation of the bolts.

**CAUTION!**
Do not energize the bushing without the correct corona shields, or a damaged corona shield, this can lead to a flashover and cause damage to the bushing.

**CAUTION!**
Make sure that the corona shield is fully clean. Contamination on the corona shield can lead to a flashover and cause damage to the bushing.

**CAUTION!**
Obey the installation instructions from the supplier of the external bus. An incorrectly installed external bus can cause external heating of the bushing.

**NOTE!**
The corona shields are delivered in separate transport boxes.

<table>
<thead>
<tr>
<th>Type</th>
<th>Corona shield outdoor article number</th>
<th>Corona shield indoor article number</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGFL 400</td>
<td>1ZSC001635-AAG</td>
<td>1ZSC001635-AAH</td>
</tr>
<tr>
<td>GGFL 420</td>
<td>1ZSC001635-AAM</td>
<td>1ZSC001635-AAL</td>
</tr>
<tr>
<td>GGFL 600</td>
<td>1ZSC001635-AAK</td>
<td>1ZSC001635-AAK</td>
</tr>
<tr>
<td>GGFL 800</td>
<td>1ZSC001635-AAJ</td>
<td>1ZSC001635-AAB</td>
</tr>
</tbody>
</table>
Procedure for installation of the outdoor/A-side corona shield

1. Apply Fomblin to the contact surface (1) on the outer terminal.

   **NOTE!**
   The grease is for surface protection, not electrical conduction. Thus a very thin film of grease is sufficient.

2. Make sure that the drainage holes (4) point down, then put the corona shield on the top end.

3. Install the external connection according to the instructions from the supplier.

4. Apply Fomblin to the bolts (3). Then install the bolts and washers.

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

5. Tighten the bolts in a crosswise sequence.

   **Torque**
   24.5 Nm ±10%

End of instruction
Procedure for installation of the indoor/B-side corona shield

1. Apply Fomblin to the contact surface (1) on the outer terminal.

   **NOTE!**
   The grease is for protection, not conduction. Thus a very thin film of grease is sufficient.

2. Put the corona shield on the top end.

3. Install the external connection according to the instructions from the supplier.

4. Apply Fomblin to the bolts (3) and install the bolts and washers.

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

5. Tighten the bolts in a crosswise sequence.

   **Torque**
   24.5 Nm ±10%

*End of instruction*
4.7 Grounding of the bushing flange

Overview

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

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

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 in the wall.

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
   M20: 120 Nm ±10%

5. Connect the other end of the flexible cable (14) to the grounding point on the wall.

   NOTE!
   This makes an electrical connection between the bushing and the wall, keeping them at the same potential.

End of instruction
**4.8 Gas-filling**

**4.8.1 Gas overview**

**Overview**

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

**DANGER!**
Risk of asphyxiation!
SF₆ 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 $P_{abs}$ 570 kPa at +20 °C. The bushings are tested for maximum operating pressure (MOP$_{abs}$) 700 kPa at high ambient temperatures.

**NOTE!**
The bushing has a bursting disc that will release pressure at $P_{abs}$ 900 kPa.
The purpose of the SF\textsubscript{6} 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 N\textsubscript{2} gas, at a transport pressure of $P_{\text{abs}}$ 125 kPa.

The bushing has three density guards. In the event of a low level of SF\textsubscript{6} gas density in the bushing, an alarm operates.

**Description of SF\textsubscript{6} gas**

Sulfur-hexafluoride (SF\textsubscript{6}) 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 SF\textsubscript{6} 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 SF\textsubscript{6} 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 CO\textsubscript{2} equivalent</td>
<td>22800</td>
</tr>
<tr>
<td>Lifetime in the atmosphere</td>
<td>3200 years</td>
</tr>
</tbody>
</table>

**Amount of SF\textsubscript{6} gas**

The approximate amount of SF\textsubscript{6} gas that is used in the bushing.

<table>
<thead>
<tr>
<th>Type</th>
<th>SF\textsubscript{6} gas</th>
<th>Carbon dioxide equivalent (CO\textsubscript{2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGFL 400</td>
<td>51 kg</td>
<td>1162.8 tonne</td>
</tr>
<tr>
<td>GGFL 420</td>
<td>52 kg</td>
<td>1185.6 tonne</td>
</tr>
<tr>
<td>GGFL 600</td>
<td>112 kg</td>
<td>2553.6 tonne</td>
</tr>
<tr>
<td>GGFL 800</td>
<td>200 kg</td>
<td>4560.0 tonne</td>
</tr>
</tbody>
</table>

**Gas pressure**

Gauge pressure ($P_g$) is atmospheric pressure, which may be approximated to $P_{\text{abs}}$ 100 kPa at sea level. Most common gas pressure gauges are calibrated to show gauge pressure, that is the pressure of the enclosed gas volume that exceeds the surrounding atmospheric pressure. Such pressure is stated as "kPa gauge" or "kPa overpressure". A pressure gauge with this presentation reads "0 kPa" when not connected to the gas valve.

Absolute pressure $P_{\text{abs}}$ is any pressure above absolute zero, a theoretical condition that would occur in empty space. Pressure values used in vacuum technology are absolute pressure, not gauge pressure. When filling a gas-insulated bushing for the first time at the ABB assembly line, the air is evacuated to a low level before adding SF\textsubscript{6}. For simplicity, we may approximate the low pressure level as vacuum. The pressure after filling may then be stated as absolute pressure, a pressure level above the vacuum condition. A pressure gauge calibrated in $P_{\text{abs}}$ would show a pressure of 100 kPa, or 1 bar, when not connected to the gas valve. The density guards supplied with the bushings are calibrated for $P_{\text{abs}}$.

The nominal SF\textsubscript{6} gas pressure for the bushing at +20 °C is $P_g$ 470 kPa (gauge), which is the same as $P_{\text{abs}}$ 570 kPa (absolute).
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>470</td>
<td>490</td>
<td>510</td>
<td>530</td>
<td>550</td>
<td>570</td>
<td>590</td>
<td>610</td>
</tr>
</tbody>
</table>

4.8.2 Electrical connections

Electrical connections from density switches

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.

<table>
<thead>
<tr>
<th>Alarm level 1 (D1: $P_{abs}$ 0.53 MPa)</th>
<th>Switch number D1 is activated, circuit 11–14 is opened and 11–12 is closed. This indicates gas density lower than level 1.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm level 2 (D2: $P_{abs}$ 0.52 MPa)</td>
<td>Switch number D2 is activated, circuit 21–24 is opened and 21–22 is closed. This indicates gas density lower than level 2.</td>
</tr>
<tr>
<td>Alarm level 3 (D3: $P_{abs}$ 0.50 MPa)</td>
<td>Switch number D3 is activated, circuit 31–34 is opened and 31–32 is closed. This indicates gas density lower than level 3.</td>
</tr>
</tbody>
</table>
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

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

I in (mA)

And the density from

\[ \rho = (\sqrt[4]{4.651 \cdot (I - 6.005) - 2.185 - 0.44})^2 \]

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. Verify that the pressure is below $P_{\text{abs}}$ 200 Pa.

3. Fill the bushing with SF$_6$ gas.

4. When the gauge of the gas-filling system indicates a pressure of about $P_{\text{abs}}$ 450 kPa ($P_e$ 350 kPa) reduce the gas-filling speed. Pay attention to the changing status in the alarm system.

   **NOTE!**
   At about $P_{\text{abs}}$ 500 kPa ($P_e$ 400 kPa) switch D3 should change status.
   At about $P_{\text{abs}}$ 520 kPa ($P_e$ 420 kPa) switch D2 should change status.

5. When switch D1 changes status at about $P_{\text{abs}}$ 530 kPa ($P_e$ 430 kPa), temporarily stop the gas-filling.

6. Stop gas-filling when the pressure is $P_{\text{abs}}$ 570 kPa ($P_e$ 470 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 29.

   **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.

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

8. Remove the gas-filling equipment.

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

![Image of density guard installation](image_url)

**Torque**
20 Nm

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, indoor/B-side (mm)</th>
<th>Flashover distance, outdoor/A-side (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGFL 400</td>
<td>3916</td>
<td>4536</td>
</tr>
<tr>
<td>GGFL 420</td>
<td>3671</td>
<td>3609</td>
</tr>
<tr>
<td>GGFL 600</td>
<td>4964</td>
<td>6164</td>
</tr>
<tr>
<td>GGFL 800</td>
<td>6720</td>
<td>8870</td>
</tr>
</tbody>
</table>
5 Recommended tests before energization

5.1 Overview

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

5.2 Measurement of capacitance

The capacitance can be measured before installation. When measuring the capacitance it is very important to have the bushing hanging in clean soft lifting slings at minimum of 3 m above ground.

Connect a measuring bridge between the outer terminal and the intermediate flange.

Measure the capacitance ($C_1$) between the outer terminal and the intermediate flange. The capacitance values are marked on the rating plate.

**NOTE!**

If the bushing is already installed when the capacitance is measured, the grounding will interfere and the measured values will differ from those on the rating plate.
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.

Heating system

A heating system is necessary for bushings operating in temperatures lower or equal to -42 °C. Information regarding installation of a heating mat is available in the document 1ZSC000563-ACB.

Cleaning of the insulator surface

The insulator surface can appear to be dirty, but this has no effect on the function of the insulator.
If the insulator is exposed to very high pollution it can be necessary to clean the surface, please refer to ABB Composites MB2193 for information about cleaning.

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.

Lubrication

After ten years of operation, it can be necessary to add grease.
If a large quantity of grease has leaked from the bushing, pump grease into the nipples.

NOTE!
In warm weather conditions the grease can become fluid, and drip from the bushing. This grease can look like oil leakage.
Measurement of capacitance

Please refer to *Measurement of capacitance*, page 35.

**NOTE!**

The measurement of capacitance when the bushing is installed in the wall, does not give the same values as measurements done by ABB.

If measurement of capacitance is necessary for maintenance purposes, the new values must be compared with older values that were measured under the same circumstances.

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.
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 $P_{\text{abs}}$ 20 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 $P_{\text{abs}}$ 20 Pa.

5. Disconnect the SF$_6$ gas service unit.
6. Remove the bursting disc (10) and O-rings (12).

7. Install the transportation support (6) and the O-ring.

8. Remove the three gas valves (7).

**NOTE!**
Keep the bolts for the gas valves, they are used again when installing the transportation supports.

**Torque**
M12 A4-80: 76 Nm ±5%
9. Install the transportation supports (5).

10. Connect the SF₆ gas service unit.

11. Fill the bushing again with dry nitrogen (N₂) to a transport pressure of P$_{abs}$ 125 kPa.

12. Disconnect the SF₆ gas service unit.

End of instruction
7.2 Re-packing of the bushing

Overview

DANGER!
Risk of asphyxiation!
Do not transport the bushing when it is filled with SF₆ gas.

Procedure

1. Lift the bushing. Refer to Lifting the bushing out of the transport box, page 13.

2. 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 voltage tap does not make contact with the transport box, or other objects.

3. 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.
4. Close the transport box.

**NOTE!**
Refer to *Lifting the transport box*, page 12 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 materials

- 40 % aluminum of various alloys.
- 30 % glass fiber reinforced epoxy.
- 23 % silicone rubber.
- 5 % stainless steel.
- 2 % copper.

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.

For the carbon dioxide (CO₂) equivalent for the SF₆ gas, see Amount of SF₆ gas, page 28.
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.
- The quality of the SF₆ gas must comply with standard IEC 60376.
- Handling and Cleaning of Composite Insulators, ABB Composites MB2193.