Transformer bushing, type GOH
Installation and maintenance guide
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1 Safety

1.1 Levels of safety risks

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

Symbols and their meanings

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

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

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

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

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

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

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

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

1.2 Hazardous working situations

<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. Then earth all objects at the workplace.</td>
</tr>
<tr>
<td></td>
<td>If work must be carried out close to live plant components, then 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.</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>Transformer oil</td>
<td>Collect used transformer oil in drums.</td>
</tr>
<tr>
<td></td>
<td>Transformer oil is dangerous. Fumes from warm oil can cause irritation to the respiratory organs and the eyes. Long and repeated contact with transformer oil can cause damage to your skin.</td>
</tr>
<tr>
<td>Waste and cleaning up</td>
<td>Clean up liquid waste with an adsorbent. Treat waste as hazardous to the environment.</td>
</tr>
<tr>
<td>Fire</td>
<td>Extinguish fire with powder, foam or carbon dioxide.</td>
</tr>
</tbody>
</table>
2 Product description

2.1 Design

Overview

The GOH is a capacitance graded oil impregnated paper bushing made for immersed oil/air service. The conductor is made from a solid aluminum cylinder that has cooling flanges on the oil side.

For a detailed description, please refer to the Technical guide, IZSE 2750-107.

General schematics

1  Outer terminal
2  Porcelain insulator
3  Mounting flange
4  Porcelain insulator
5  Oil-side terminal with cooling flanges
6  Test tap
**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 500 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.

---

**Test adapter, 1ZSC003881-AAC, optional equipment**

The test adapter 1ZSC003881-AAC is available for permanent connection to measuring circuits. Please refer to Test adapter – Installation and maintenance guide 1ZSC000563-ACD.
2.2 Technical specifications

2.2.1 General specifications

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

<table>
<thead>
<tr>
<th>Application</th>
<th>Transformers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification:</td>
<td>Transformer bushing</td>
</tr>
<tr>
<td></td>
<td>• Oil impregnated paper, capacitance graded, oil immersed.</td>
</tr>
<tr>
<td></td>
<td>• For outdoor and indoor use.</td>
</tr>
<tr>
<td>Ambient temperature limits:</td>
<td>-40 °C to +40 °C.</td>
</tr>
<tr>
<td></td>
<td>(-50 °C according to GOST 10693-81 item 2.26.)</td>
</tr>
<tr>
<td>Maximum altitude of site:</td>
<td>1000 m (Bushings for other altitudes can be provided on request.)</td>
</tr>
<tr>
<td>Level of rain and humidity:</td>
<td>1-2 mm rain/minute horizontally and vertically, according to IEC 60060-1 and IEEE Std 4.</td>
</tr>
<tr>
<td>Maximum pollution level:</td>
<td>According to the specific creepage distance, and IEC 60815.</td>
</tr>
<tr>
<td>Immersion medium:</td>
<td>Transformer oil.</td>
</tr>
<tr>
<td></td>
<td>• Maximum daily mean oil temperature: +90 °C.</td>
</tr>
<tr>
<td></td>
<td>• Maximum temporary oil temperature, at normal load: +100 °C.</td>
</tr>
<tr>
<td></td>
<td>• Maximum temporary oil temperature, at short time overload: +115 °C.</td>
</tr>
<tr>
<td>Oil-level in transformer:</td>
<td>Not lower than 25 mm from the bushing flange.</td>
</tr>
<tr>
<td>Maximum pressure of medium:</td>
<td>$p_g$ 100 kPa ($p_g$ = relative to ambient pressure).</td>
</tr>
<tr>
<td>Angle of installation:</td>
<td>• 0 to 45° from vertical.</td>
</tr>
<tr>
<td></td>
<td>• 90° from vertical (horizontal position).</td>
</tr>
<tr>
<td>Test tap:</td>
<td>Test tap with 4 mm male contact pin.</td>
</tr>
<tr>
<td>Capacitance $C_2$ of test tap:</td>
<td>&lt;5000 pF</td>
</tr>
<tr>
<td>Arcing horns:</td>
<td>N/A</td>
</tr>
<tr>
<td>Conductor:</td>
<td>Solid aluminum conductor.</td>
</tr>
<tr>
<td>Markings:</td>
<td>Conforming to IEC/IEEE.</td>
</tr>
</tbody>
</table>

2.2.2 Mechanical loading

Maximum permitted static load on the outer terminal

The load must be applied at the midpoint of the outer terminal or below. The total cantilever load must be perpendicular to the bushing axis. The bushing installation angle can be 0° – 45° from vertical, or 90° from vertical (horizontal position).

NOTE!
The loads described in this section are static loads, for dynamic loads such as earthquakes and extreme weather conditions, please contact your ABB sales representative.
1 Maximum cantilever load
2 Maximum axial static load
3 Load applied below the midpoint

<table>
<thead>
<tr>
<th>Type</th>
<th>Type test load 1 minute (N)</th>
<th>Maximum cantilever operating load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOH 170/10</td>
<td>10000</td>
<td>1575</td>
</tr>
<tr>
<td>GOH 170/16</td>
<td>10000</td>
<td>1575</td>
</tr>
<tr>
<td>GOH 170/25</td>
<td>10000</td>
<td>1575</td>
</tr>
</tbody>
</table>
3 Delivery

3.1 Receiving inspection

- Make sure that all items are 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 vertical position. Keep the bushings dry, clean and protected against mechanical damage.
- Carefully inspect the bushing for damage after transportation.

3.3 Storage

Short and long term storage

- 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 must be stored in the vertical position, with the top end upwards. The transport box is marked with Top end.
3.4 Lifting

3.4.1 Lifting of the transport box

Overview

![Diagram showing lifting points]

1. Center of gravity
2. Forklift lifting points

Procedure

1. Make sure that the crane and the soft lifting slings can lift the transport box with the bushing. Refer to the weight in the packing list.

2. Attach soft lifting slings to the correct locations.

3. Carefully lift the transport box.

4. Put down the transport box on flat ground.

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

Overview

Procedure

1. Make sure that the crane can lift the bushing. Refer to the weight on the rating plate.

2. Open the transport box.

   NOTE!
   The cover is attached with bolts.

3. Attach a soft lifting sling to the lifting eye on the top and to the crane hook.

4. Carefully lift the bushing.

5. Lower the bushing onto soft bedding.

End of instruction
## 4 Installation

### 4.1 Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Part number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifting tool</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soft bedding</td>
<td>-</td>
<td>E.g. rubber mat or wood board</td>
</tr>
<tr>
<td>Soft lifting slings</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Torque wrench key for hex socket screws, 18 mm (M12), 16 mm (M10) and 13 mm (M8), torque 20 to 60 Nm.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wrench for hex socket screws 30 mm or adjustable wrench for 30 mm bolts or larger.</td>
<td>-</td>
<td>For the test tap cover.</td>
</tr>
<tr>
<td>Tackle</td>
<td>-</td>
<td>For installation of the bushing at a specific angle.</td>
</tr>
</tbody>
</table>

### 4.2 Consumables

<table>
<thead>
<tr>
<th>Item</th>
<th>Brand</th>
<th>Part number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil based Vaseline</td>
<td>Unilever</td>
<td>1171 5011-102</td>
<td>For treatment of contact surfaces. Does not react with transformer oil.</td>
</tr>
<tr>
<td>Mobilgrease 28</td>
<td>MOBIL</td>
<td>11714014-407</td>
<td>Lubricates and protects metals against corrosion. Protects rubber. Does not react with transformer oil.</td>
</tr>
<tr>
<td>Penetrox A</td>
<td>Burndy</td>
<td>-</td>
<td>For aluminum to aluminum contact surfaces.</td>
</tr>
</tbody>
</table>
4.3 Preparations

4.3.1 Lifting the bushing

Overview

1. Soft bedding, e.g. rubber mat or woodboard
2. Lifting eye

Procedure

1. Make sure that the crane can lift the bushing. Refer to net weight in the packing list.
2. Remove the transport securing device.
3. Attach a soft lifting sling to the lifting eye and to the crane hook.
4. For installation at a specific angle: attach soft lifting slings with a shackle from the flange to the crane hook.
5. Align the crane hook with the lifting tool on the bushing.
6. Carefully lift the bushing.

CAUTION!
Make sure that the bushing does not rotate. Rotation can unscrew the lifting eye and the bushing can fall.

End of instruction
4.4 Installation on the transformer

4.4.1 Installation in the vertical position

When the bushing is installed in the vertical position, the bushing's internal oil expansion-system is used. The oil-plugs must not be removed.

Procedure

1. Lift the bushing to a position above the transformer.

2. Lower the bushing onto the transformer.

CAUTION!
Do not cause damage to the stud bolts. There is a risk of metal falling into the transformer.

NOTE!
Plastic sleeves put on two or three of the stud bolts will help to guide the flange, and will prevent damage to the stud bolts.
3. Make permanent markings for the correct installation at site:
   1. Make sure that the bushing is installed in the correct orientation.
   2. Make permanent markings (16) on the bushing flange and the transformer turret.

4. Install the nuts and washers.

   ![Diagram of installation steps]

   **Torque**
   Refer to the transformer manufacturer.

---

End of instruction
4.4.2 Installation at an angle

When the bushing is installed at an angle, the transformer oil-conservator is used. The oil-plug for the oil-passage must be removed.

Procedure

1. Lift the bushing to a position above the opening in the transformer.
   Make sure that the oil-passage plug (1) on the middle flange points straight down.

2. Put a container under the oil-passage plug (1).
   **NOTE!** The quantity of oil to drain is approximately 10 L.

3. Drain the oil from the bushing:
   1. Remove the oil-passage plug (1).
   2. Install the oil-passage plug (1) in the tapped hole (2).
   3. Wait until all the oil has drained from the bushing.
4. Lower the bushing onto the transformer.

**CAUTION!**
Do not cause damage to the stud bolts. There is a risk of metal falling into the transformer.

**NOTE!**
Plastic sleeves put on two or three of the stud bolts will help to guide the flange, and will prevent damage to the stud bolts.

5. Install the nuts and washers.

**Torque**
Refer to the transformer manufacturer.

End of instruction
4.4.3 Installation in the horizontal position

When the bushing is installed in the horizontal position, the transformer oil-conservator is used. The oil-plug for the oil-passage must be removed.

Procedure

1. Lift the bushing to a position in front of the opening in the transformer.
   Make sure that the oil-passage plug (1) on the middle flange points straight up.

2. Remove the oil-passage plug (1), and install it in the tapped hole (2).
3. Push the bushing against the transformer.

**CAUTION!**
Do not cause damage to the stud bolts. There is a risk of metal falling into the transformer.

**NOTE!**
Plastic sleeves put on two or three of the stud bolts will help to guide the flange, and will prevent damage to the stud bolts.

4. Install the nuts and washers.

**Torque**
Refer to the transformer manufacturer.

End of instruction
4.4.4 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. Put a flexible cable (14) between the grounding hole in the bushing flange and a grounding point on the transformer.

2. 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.

3. Install the bolt (13).
   
   **Torque**
   M12: 40 Nm

4. 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
4.4.5 Installation of oil-side conductors

Overview

The terminals have many bolt holes for the installation of oil-side connectors, to make many distinct points with defined, and relatively high contact pressure. ABB recommends a thickness of the oil-side connectors that is less than the radius of the plain washer. It should have a flatness deviation that is not more than 0.1 mm, and is sufficiently rough (Ra 6.3).

The standard surfaces of the oil-side connections are plated with a tin-zinc alloy, called Firinite. With Firinite, coated conductors can be installed without special treatment, such as wire brushing.

For the long term stability of the connection, it is good to limit the number of materials in the conductor. To get optimal contact, use aluminum conductors with tin coating.

General requirements for good electrical conduction

• The contact surfaces must be clean.
• The oxide on connected terminals must be removed according to the instructions

CAUTION!
Failure to obey these instructions will cause the connections to overheat.

CAUTION!
Do not use stainless steel bolts, or bolts with coating on the oil side terminal. Stainless steel can easily be mistaken for shiny zinc-coating. The risk of the thread cutting is also increased if stainless steel is used.

Preparation of uncoated conductors

1. Remove oxide with abrasive cloth, or a stainless steel brush.

   NOTE!
   ABB recommends scotch-brite (brown) or abrasive cloth with similar properties.

2. Apply Vaseline on the entire surface, and rub (or brush) the surface in two directions until the entire surface has been treated.

   NOTE!
   Or use a grease with equal properties to Vaseline.

3. Remove all the contaminated grease, and apply new contact grease on the surfaces. Remove excess grease.

End of instruction
Installation of conductors

1. Inspect bushings oil-side terminals, and clean them with a dry cloth.

   **CAUTION!**
   Do **NOT** use a wire brush.

   **NOTE!**
   The terminals are covered with Vaseline when delivered from ABB.

2. Apply new Vaseline on the surface of the contact, and remove excess Vaseline.

   **NOTE!**
   Or use a grease with equal properties to Vaseline.

3. Install the flexible conductors (1):
   1. Apply lubricant to the flexible conductors (1).
   2. Install the flexible conductors (1) with the bolts (3), spring washers (5), and flat washers (3), but do not tighten the bolts (3).
      Make sure that the flat washer (3) has a larger diameter than the spring washer (5).
      Make sure that bolts (3) have a minimum inset of 18 mm, and 30 mm maximum inset, in the oil-side contact.
      Refer to Consumables, page 15.

   **CAUTION!**
   Install the bolts (3) by hand, and make sure that they are correctly seated in the threads. The oil-side terminal bolt holes have stainless thread inserts.

   **NOTE!**
   Untreated washers and black oxide bolts of steel (property class 8.8) are recommended.

4. Turn the bolts (3) by hand until they are fully seated, to make sure that they do not bottom out in the oil-side terminal bolt holes.
4.4.6 Installation of air-side conductors

Overview

The terminals have many bolt holes for the installation of connectors, to make many distinct points with defined, and relatively high contact pressure. ABB recommends a thickness of the opposite contact that is less than the radius of the plain washer. It should have a flatness deviation that is not more than 0.1 mm, and is sufficiently rough (Ra 6.3).

The standard surfaces of the oil-side connections are plated with a tin-zinc alloy, called Firinite. With Firinite, coated conductors can be installed without special treatment, such as wire brushing.

Both sides of the terminal plates are plated, and can be used for connection.

For the long term stability of the connection, it is good to limit the number of materials in the conductor. To get optimal contact, use aluminum conductors with tin coating.

General requirements for good electrical conduction

• The contact surfaces must be clean.
• The oxide on connected terminals must be removed according to the instructions.

CAUTION!
Failure to obey these instructions will cause the connections to overheat.

<table>
<thead>
<tr>
<th>Plating</th>
<th>Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum + tin plating</td>
<td>Excellent (recommended)</td>
</tr>
<tr>
<td>Aluminum + silver plating</td>
<td>Good</td>
</tr>
<tr>
<td>Copper (no plating)</td>
<td>Good</td>
</tr>
<tr>
<td>Copper + tin plating</td>
<td>Good</td>
</tr>
<tr>
<td>Copper + silver plating</td>
<td>Good</td>
</tr>
<tr>
<td>Aluminum (no plating)</td>
<td>Poor (not recommended)</td>
</tr>
</tbody>
</table>

Preparations for uncoated conductors before mounting

1. Remove oxide with abrasive cloth, or a stainless steel brush.

   NOTE!
   ABB recommends scotch-brite (brown) or abrasive cloth with similar properties.

2. Apply Vaseline on the entire surface, and rub (or brush) the surface in two directions until the entire surface has been treated.

   NOTE!
   Or use a grease with equal properties to Vaseline.
3. Remove all the contaminated grease, and apply new contact grease on the surfaces. Remove the excess grease.

End of instruction

Installation of conductors

1. Inspect bushings air-side terminals, and clean them with a dry cloth.

   ! CAUTION!
   Do NOT use a wire brush.

   ! NOTE!
   At delivery the terminals are treated with Vaseline.

2. Apply new contact grease on the surface, and remove excess grease.

3. Install the flexible conductors (1):
   1. Apply lubricant to the flexible conductors (1), and the bolts (3).
   2. Install the flexible conductors (1) with the bolts (3), spring washers (5), flat washers (3), and nuts (5), but do not tighten the bolts (3).
      Make sure that the flat washer (3) has a larger diameter than the spring washer (5).
      Refer to Consumables, page 15.

   ! CAUTION!
   Make sure that there are spring washers (5), and flat washers (3) installed on both sides of the terminal plates.

4. Tighten the bolts (3).

   ! Torque
   M12: 60 Nm

End of instruction
4.5 Oil-filling

Overview

This section does not apply to bushings that are installed in the vertical position, because they are not connected to the transformers oil system.

Oil-filling with vacuum

When the transformer oil-filled with the vacuum process, the bushing will be completely oil-filled and thus venting of the bushing is not necessary. The expansion of oil in the bushing is done by the oil system of the transformer.

Oil-filling without vacuum

1. Fill the transformer with oil to the correct oil-level.

2. For bushings installed in the horizontal position:
   1. Remove the plug (3).
   2. Wait until all the air has released from the bushing.
   3. Install the plug (3).

3. For bushings installed at an angle:
   1. Remove the plug (9).
   2. Wait until all the air has released from the bushing.
   3. Install the plug (9).

End of instruction
5 Commissioning

5.1 Waiting time before energization

General requirements for the bushing

- If the bushing has been stored in the vertical position with the top end upwards, then no waiting time is required.
- If the bushing has been stored in the horizontal position, then air bubbles must be removed from the oil before it can be energized. Refer to the table.
- The waiting times can be met with the bushing installed on the transformer.

When the bushing is in the vertical position, air bubbles that are trapped in the oil collects at the top.

<table>
<thead>
<tr>
<th>Storage time in the horizontal position</th>
<th>Minimum required waiting time in the vertical position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before service voltage application</td>
</tr>
<tr>
<td>Less than one year</td>
<td>12 hours</td>
</tr>
<tr>
<td>More than one year</td>
<td>7 days</td>
</tr>
</tbody>
</table>

⚠️ CAUTION!
If you do not obey this procedure, flashovers or partial discharges can occur inside the bushing.

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.

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

5.2.1 Overview

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

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

5.2.2 Tightness test between transformer and bushing flange

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

The measurements can be done with a measuring bridge directly connected to the test tap, or with ABB’s test adapter (IZSC003881-AAC).

• $C_1$ 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 δ).

Nominal capacitance

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Catalog No</th>
<th>Nominal capacitance (pF)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$C_1$</td>
</tr>
<tr>
<td>GOH 170/10</td>
<td>LF 126 007-</td>
<td>400</td>
</tr>
<tr>
<td>GOH 170/16</td>
<td>LF 126 008-</td>
<td>570</td>
</tr>
<tr>
<td>GOH 170/25</td>
<td>LF 126 009-</td>
<td>765</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>2749 528-B</td>
</tr>
<tr>
<td>O-ring</td>
<td>1ZSC001606-AAW</td>
</tr>
</tbody>
</table>

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

5. Measure the capacitance \(C_1\) between the outer terminal and the stud (1).
   
   **NOTE!**
   Refer to the table for the nominal capacitance \(C_1\), *Nominal capacitance*, page 32.

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
5.2.4 Measurement of through-resistance

Overview

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

(U: Measured voltage drop; I: Through-current; R: Total circuit resistance).

The total through-resistance is the sum of the transformer winding, lead resistance, the bushing conductor, and contact resistance. The additional resistance from the bushing conductor should not be more than 10 to 100 m\( \Omega \). Because the through-resistance of the HV winding of a typical power transformer is in the order of 0.1 to 1 \( \Omega \), this is a very rough method that can only be used to detect very large faults in the current path, such as open circuits.

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

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

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 draw rod is 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
5.3 Transformer-factory test

Risk of gas-bubble evolution during transformer-factory tests

When the temperature of a sealed oil-impregnated bushing increases, the thermal expansion of the oil increases the pressure, and nitrogen in the expansion space dissolves into the oil. At rapid cooling, the oil becomes oversaturated with nitrogen and bubbles can evolve. Such bubbles have caused partial discharges and dielectric failures at transformer-factory tests, where a heat-run was followed by fast cooling and dielectric testing.

If a bushing generates bubbles at the transformer-factory tests, it is recommended to open the bushing to the atmosphere during the heat-run, and during the following dielectric tests. It is not necessary to pressurize the bushing during the dielectric tests.

If the heat-run was done with the bushing sealed, and unexpected bubbles and partial discharges appear at the dielectric tests, the bushing can be opened at this stage.

The bushings are filled with degassed oil and are sealed at atmospheric pressure. There is an air cushion in the bushings expansion space at the top. During transport and handling, some of the gas molecules become dissolved into the oil, and thus the pressure in the bushing decreases below atmospheric pressure. Opening the bushing to the atmosphere at the transformer dielectric tests will increase the pressure to atmospheric, and thus instantly decrease the oversaturation.

Bushings that are installed in the horizontal position, or at an angle do not generate gas bubbles, because the connection to the transformer oil system keeps the oil at the correct pressure.

A detailed explanation of the gas bubble-evolution phenomenon is given in product information: 1ZBC000001C2704, "Gas bubble evolution in oil impregnated bushings".

Procedure, opening the bushing for heat-run and dielectric tests

1. Remove the oil-filling plug (9).

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

2. Do the tests.
3. When the testing is completed:
   1. Put a new gasket on the plug (9).
   2. Install the plug (9).

   Gasket part number: 2750 515-142.

   **CAUTION!**
   Make sure that temperature of the bushing is between +5 °C and +35 °C when installing the plug (9).

   If the bushing is sealed at the wrong temperature, or not correctly sealed, the bushing can fail at operation.

   **NOTE!**
   It is not necessary to pressurize the bushing when it is sealed.

---

End of instruction
6 Maintenance

6.1 Recommended maintenance

General

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

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

Cleaning of the insulator surface

If the insulator shed 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 insulator sheds with a high pressure water jet. This can cause damage to the insulator sheds.

Measurement of capacitance and dissipation factor

Please refer to Measurement of capacitance and dissipation factor, page 32.

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. Refer to Measurement of capacitance and dissipation factor, page 32.
6.2 Taking an oil sample

Overview

Taking oil samples is generally not recommended.

Take an oil sample only if a problem is known, for example a high power factor over $C_1$, or visible oil leakage. For more information, please refer to product information 2750 515-142 "Bushing diagnostics and conditioning".

NOTE!
The mean temperature of the bushing must be between 5° and 35° C when an oil-sample is taken.

Procedure

1. Remove the oil-plug at the top of the bushing (9).

   CAUTION!
   Install the oil-plug as soon as possible, contamination can enter the bushing.

2. Suck the oil sample from the bushing through a rubber hose with a syringe, or a pump.

   CAUTION!
   Do not use a metal pipe to suck the oil. A metal pipe can cause damage to the inner parts of the bushing.
3. Install the oil plug (9) with a new gasket, and tighten the oil plug.

Gasket part number: 2152 899-132

<table>
<thead>
<tr>
<th>Gasket</th>
<th>d (mm)</th>
<th>D (mm)</th>
<th>T (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M8</td>
<td>8</td>
<td>16</td>
<td>3</td>
</tr>
</tbody>
</table>

Torque
M8: 20 Nm

End of instruction
6.3 Checking the oil-level

Overview

Procedure

1. Remove the oil-plug (9).

   ! WARNING!
   Be careful when the oil-plug is removed, contamination can enter the bushing.

2. With a clean dipstick, check the oil-level.

<table>
<thead>
<tr>
<th>Type GOH</th>
<th>Oil level at 20 ±10 °C, mm</th>
<th>Temperature correction mm/10 °C (The bushing in vertical position)</th>
</tr>
</thead>
<tbody>
<tr>
<td>170/10</td>
<td>95 ±5</td>
<td>2.5</td>
</tr>
<tr>
<td>170/16</td>
<td>95 ±5</td>
<td>2.5</td>
</tr>
<tr>
<td>170/25</td>
<td>95 ±5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

3. If the oil-level is low, fill the bushing with transformer oil.
   1. Fill the bushing with transformer oil.
   2. Install and tighten the oil-plug (9).
      
      Use a new gasket, part number: 2750 515-142.

   ! WARNING!
   Do not use a pipe to fill the bushing with transformer oil, it can cause damage to the parts in the bushing. Use a plastic or rubber hose.

End of instruction
7 Re-packing

7.1 Removal of bushings installed at an angle, or in the horizontal position

This procedure applies to bushings that are connected to the transformer oil-system. It is important to remove a small quantity of transformer oil to make space for thermal expansion.

Procedure

1. Remove the bushing from the transformer.

2. Remove the oil-plug (2), and install it in the oil-side hole (1).

3. Put the bushing in the vertical position.
4. Remove the plug (9).

5. With a dry and clean dipstick, check the oil-level through the oil-filling hole (9).

6. Remove, or fill transformer oil until the oil-level is correct for storage.
   Use a rubber hose with a syringe, or a pump.

<table>
<thead>
<tr>
<th>Type GOH</th>
<th>Oil level at 20 ±10 °C, mm</th>
<th>Temperature correction mm/10 °C (The bushing in vertical position)</th>
</tr>
</thead>
<tbody>
<tr>
<td>170/10</td>
<td>95 ±5</td>
<td>2.5</td>
</tr>
<tr>
<td>170/16</td>
<td>95 ±5</td>
<td>2.5</td>
</tr>
<tr>
<td>170/25</td>
<td>95 ±5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

   **CAUTION!**
   Do not use a metal pipe to suck the oil. A metal pipe can cause damage to the inner parts of the bushing.

7. Install the oil plug (9) with a new gasket, and tighten the oil plug.
   Gasket part number: 2152 899-132

   **NOTE!**
   Use only a gasket that is made from nitrile rubber, with a hardness of 70 shore. Other materials will cause oil-leakage.

<table>
<thead>
<tr>
<th>Gasket</th>
<th>d (mm)</th>
<th>D (mm)</th>
<th>T (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M8</td>
<td>8</td>
<td>16</td>
<td>3</td>
</tr>
</tbody>
</table>

   **Torque**
   20 Nm

End of instruction
7.2 Re-packing of the bushing

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!
   Make sure that the there is soft bedding in the transport box.

   ! CAUTION!
   Make sure that the test 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 of 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. Obey 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 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 experience in each country. Non-recyclable components should be sent to an approved environmental waste treatment plant for destruction or disposal.

The bushing has these parts and materials

• The conductor is made of low-alloy aluminum.
• The terminals are made of low-alloy aluminum plated with tin-zinc.
• Transformer oil, refer to IEC 60296, group 1.
• The condenser core is made of paper and 1 % aluminum foil, impregnated with transformer oil.
• The spring device (rings) is made of aluminum alloy.
• The spring washers and cylindrical pins are made of steel.
• The cover for the test tap is made of steel.
• The insulators are made of quartz or aluminum-silicate porcelain.

Porcelain

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

Electronics

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

Metals should be sorted according to type and surface coating, and sent to an approved recycling company. 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 paths, contacts and cables. Some contacts are silver-plated. Fumes from some metals may cause environmental damage, this applies to copper, zinc and nickel, which are used sparingly as surface coatings.

Plastics

The different types of plastic should be separated and sent to an approved environmental waste treatment plant or recycling company. The energy content in thermoplastics and thermosetting plastics can often be recovered through combustion at a plant 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 company. By utilizing gravimetric forces, oil waste can be separated into oil, water and a range of contaminants. In many cases, the oil can then be reused. 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.