Transformer bushing, type GOE 250 to 2550
Installation and commissioning guide
The information contained in this document may be subject to change without prior warning and should not be considered as binding on ABB AB’s behalf. ABB AB accepts no liability for any errors that may appear in this document. ABB AB is not liable for any damage resulting from the incorrect interpretation of this document. This document, or parts thereof, may not be reproduced or copied without ABB AB’s consent. It may not be distributed to others, or used by unauthorized parties. Any breaches to the above will be penalized with the support of applicable laws.
Contents

1 Safety ........................................................................................................................................................................ 5
  1.1 Levels of safety risks ................................................................................................................................................. 5
  1.2 Hazardous working situations ................................................................................................................................. 6
  1.3 Safety precautions ....................................................................................................................................................... 6
  1.4 Competence level ......................................................................................................................................................... 6

2 Product description ........................................................................................................................................................ 7
  2.1 Design .......................................................................................................................................................................... 7
  2.2 Technical specification ................................................................................................................................................. 12
    2.2.1 General specifications ......................................................................................................................................... 12
    2.2.2 Mechanical loading ............................................................................................................................................. 12

3 Delivery ............................................................................................................................................................................ 15
  3.1 Incoming inspection ..................................................................................................................................................... 15
  3.2 Transportation ............................................................................................................................................................ 15
  3.3 Storage ...................................................................................................................................................................... 15
  3.4 Lifting .......................................................................................................................................................................... 16
    3.4.1 Lifting the transport box ..................................................................................................................................... 16
    3.4.2 Lifting the bushing out of the transport box ................................................................................................. 17

4 Installation ....................................................................................................................................................................... 19
  4.1 Tools ............................................................................................................................................................................ 19
  4.2 Consumables ............................................................................................................................................................. 19
  4.3 Preparations ............................................................................................................................................................... 20
    4.3.1 Lifting the bushing .............................................................................................................................................. 20
    4.3.2 Oil-filling of the bushing for horizontal installation .......................................................................................... 22
  4.4 Horizontal installation of the bushing on the transformer ....................................................................................... 24
  4.5 Installation with draw lead ........................................................................................................................................ 26
    4.5.1 Calculation of the length of the draw lead ......................................................................................................... 26
    4.5.2 Installation with draw lead .................................................................................................................................. 27
  4.6 Installation with draw rod at transformer factory ................................................................................................... 32
    4.6.1 Removal of the lower draw rod with bottom contact from the bushing ...................................................... 32
    4.6.2 Installation of the small bottom contact in the transformer ........................................................................... 36
    4.6.3 Installation of the large bottom contact in the transformer ............................................................................. 38
    4.6.4 Installation of the bushing on the transformer ................................................................................................. 40
  4.7 Installation with draw rod at site ............................................................................................................................... 44
    4.7.1 Preparations at site ................................................................................................................................................. 44
    4.7.2 Installation of the bushing on the transformer at site ......................................................................................... 47
  4.8 Hydraulic tightening of the draw-rod nut .................................................................................................................... 51
  4.9 Manual tightening of the draw-rod nut ....................................................................................................................... 55
  4.10 Oil-filling .................................................................................................................................................................... 57
  4.11 Installation of the outer terminal ............................................................................................................................. 58
  4.12 Grounding of the bushing flange ............................................................................................................................ 61

5 Commissioning ............................................................................................................................................................... 63
  5.1 Waiting time before energization ............................................................................................................................ 63
  5.2 Recommended test before energization ................................................................................................................... 64
    5.2.1 Overview ............................................................................................................................................................. 64
Installation and commissioning guide

5.2.2 Tightness test between transformer and bushing flange

5.2.3 Tightness test of bushing outer terminal

5.2.4 Measurement of capacitance and dissipation factor

5.2.5 Measurement of through-resistance

6 Maintenance
6.1 Recommended maintenance

7 Re-packing
7.1 Removal of horizontally installed bushings

7.2 Removal of the bushing from the transformer, draw rod

7.3 Re-packing of the bushing

8 Spare parts and special tools
8.1 Summary

8.2 Spare parts

8.3 Special tools

9 Disposal and environmental information
9.1 Overview

9.2 Disposal and recycling

10 References
10.1 Summary
1 Safety

1.1 Levels of safety risks

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

Symbols and their meanings

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

DANGER!

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

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

CAUTION!

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

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

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

NOTE!

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

Torque

The torque symbol indicates tightening torque.
1.2 Hazardous working situations

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

1.3 Safety precautions

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

1.4 Competence level

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

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

2.1 Design

Overview

The GOE is a capacitance graded oil impregnated paper bushing made for immersed oil/air service.
For a detailed description, please refer to the Technical guide, IZSE 2750-105.

General schematics

1. Top housing
2. Porcelain insulator, air side
3. Test tap
4. Extension for current transformer
5. Porcelain insulator, oil side
6. Bottom nut
7. Mounting flange
8. Oil sampling valve
9. Oil plug
10. Oil-level gauge, GOE 1050 to 2600
11. Lifting eye
12. Sight glass, GOE 250 to 950
Terminal system

The bushing can be configured with one of two terminal systems: the draw-lead system, or the draw-rod system.

The draw-rod system can be configured with a small, or a large bottom contact.

<table>
<thead>
<tr>
<th>Terminal system</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draw-lead system</td>
<td>-</td>
</tr>
<tr>
<td>Draw-rod system</td>
<td>Small bottom contact</td>
</tr>
<tr>
<td></td>
<td>Large bottom contact</td>
</tr>
</tbody>
</table>

A  Draw-lead system
B  Draw-rod system with small bottom contact, N1 = 4
C  Draw-rod system with large bottom contact, N1 = 6
1  Inner terminal
2  Draw lead
3  Draw rod
4  Small bottom contact, N1 = 4
5  Large bottom contact, N1 = 6
Draw-rod system

The draw rod can be configured with an optional joint (3) to fit transformers with short bushing turrets. The bottom-contact joint (6) is locked with threadlocking fluid as standard, but can be unlocked as an option. Large bushings with long draw rods have one or two upper joints (1), they are always locked with threadlocking fluid. All joints must be locked with threadlocking fluid when the bushing is in operation at site.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Upper joint (only on large bushings).</td>
</tr>
<tr>
<td>2</td>
<td>Lower joint (at flange level).</td>
</tr>
<tr>
<td>3</td>
<td>Additional joint (option).</td>
</tr>
<tr>
<td>4</td>
<td>Thread is locked with threadlocking fluid.</td>
</tr>
<tr>
<td>5</td>
<td>Thread is NOT locked with threadlocking fluid.</td>
</tr>
<tr>
<td>6</td>
<td>Bottom-contact joint, locked with threadlocking fluid. Unlocked as option.</td>
</tr>
</tbody>
</table>
Horizontal installation

⚠️ CAUTION!
Do not install bushings that does not have the oil passage (2) in the horizontal position.

If the bushing will be installed in the horizontal position, then this must be specified in the order. Because horizontally installed bushings must be fully filled with oil (there is no expansion space for the oil), the oil must flow freely to and from the transformer tank through an oil passage (2).

The bushing is delivered with expansion space for the oil, and the bushing must be filled at installation.

When the bushing is delivered, the oil passage (2) is covered with a covering plate (1) and a rubber gasket. This configuration makes sure that it will be removed at installation on the transformer.

<table>
<thead>
<tr>
<th>Type</th>
<th>Dimension A (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOE 250 - GOE 450</td>
<td>55</td>
</tr>
<tr>
<td>GOE 550 - GOE 950</td>
<td>60</td>
</tr>
<tr>
<td>GOE 1050 - GOE 1175</td>
<td>67</td>
</tr>
</tbody>
</table>
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 $20 \text{kV}_{\text{rms}}$. The test tap can be used as a power source, if it is connected to an external capacitance. The operating voltage is limited to 6 kV.

**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, 2769 522-C, optional equipment**

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

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/reactors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification:</td>
<td>Transformer bushing • Oil impregnated paper, capacitance graded, oil immersed. • For outdoor and indoor use.</td>
</tr>
<tr>
<td>Ambient temperature limits:</td>
<td>-50 °C to +40 °C, limit temperatures, according to temperature class 2 of IEC 60137.</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. • Maximum daily mean oil temperature: +90 °C. • Maximum temporary oil temperature, at short time overload: +115 °C.</td>
</tr>
<tr>
<td>Oil-level in transformer:</td>
<td>Not lower than 30 mm from the bushing flange.</td>
</tr>
<tr>
<td>Maximum pressure of medium:</td>
<td>$p_g \leq 100 \text{kPa}$ ($p_g$ = relative to ambient pressure).</td>
</tr>
<tr>
<td>Angle of installation:</td>
<td>0 to 60° from vertical. (GOE 1300, 1425 and 2550-1675 0° to 30°.)</td>
</tr>
<tr>
<td>Test tap:</td>
<td>Test tap with 8 mm male contact pin. According to IEEE type A.</td>
</tr>
<tr>
<td>Conductor:</td>
<td>Center-tube conductor, or draw lead.</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 below the midpoint of the outer terminal. The total cantilever load must be perpendicular to the bushing axis. The bushing installation angle can be 0° – 60° from vertical.

Only bushings that are specified for horizontal installation can be installed at 90° from vertical.

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

**NOTE!**
The loads described in this section are static loads, for dynamic loads such as earthquakes and extreme weather conditions, please contact your ABB sales representative.
1 Maximum cantilever load at installation angle 0°
2 Maximum cantilever load at installation angle 30°
3 Maximum cantilever load at installation angle 60°
4 Maximum axial static load
5 Load applied at the midpoint

<table>
<thead>
<tr>
<th>Type</th>
<th>Test load 1 minute (N)</th>
<th>Maximum cantilever load in operation at installation angle (N)</th>
<th>Maximum axial static load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0°</td>
<td>30°</td>
</tr>
<tr>
<td>GOE 250, 380, 650</td>
<td>5700</td>
<td>2800</td>
<td>2300</td>
</tr>
<tr>
<td>GOE 950</td>
<td>5000</td>
<td>2500</td>
<td>2000</td>
</tr>
<tr>
<td>GOE 1050</td>
<td>13000</td>
<td>6500</td>
<td>4300</td>
</tr>
<tr>
<td>GOE 1175</td>
<td>12000</td>
<td>6000</td>
<td>4300</td>
</tr>
<tr>
<td>GOE 1300, 1425</td>
<td>9000</td>
<td>4500</td>
<td>2500</td>
</tr>
<tr>
<td>GOE 1550, 1675, 1800</td>
<td>13000</td>
<td>6500</td>
<td>4300</td>
</tr>
<tr>
<td>GOE 2550 - 1600</td>
<td>13000</td>
<td>6500</td>
<td>3700</td>
</tr>
<tr>
<td>GOE 2550 - 1675</td>
<td>12200</td>
<td>6100</td>
<td>2900</td>
</tr>
</tbody>
</table>

**Maximum permitted torque on the outer terminal**

The maximum torque that is permitted on the outer terminal is 250 Nm.
3 Delivery

3.1 Incoming inspection

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

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

NOTE!
The oil-level is not shown correctly when the bushing is in the horizontal position.

3.2 Transportation

• The bushing must be transported in the transport box.
• The bushing must be transported in the horizontal position.
• 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 can be stored in both the vertical, and horizontal positions.

NOTE!
The oil-level is not shown correctly when the bushing is in the horizontal position.
Long term storage, more 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.
- Lift the bushing to the vertical position with the top end upwards, and put it in a safe stand.
  - As an alternative: keep the bushing in the transport box and lift it to an inclined position, with the top end upwards and at an angle of at least 7°.

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 Top end, this identifies the end to lift when the bushing is in storage.

3.4 Lifting

3.4.1 Lifting the transport box

Overview

1 Center of gravity
2 Soft lifting slings
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. Refer to the net weight on the packing list.

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 lower part of the flange and then to the crane hook.

5. Attach a soft lifting sling to the outer terminal (1) and then to the crane hook.

   CAUTION!
   Attach the soft lifting sling as close to the top housing as possible, or damage will occur.

   NOTE!
   If the outer terminal is not installed, please contact ABB.

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 ceramic insulator, it will break.

8. Lower the bushing onto the support blocks.

End of instruction
## 4 Installation

### 4.1 Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Part number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifting tool</td>
<td>9760 668-A</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>Pull-through cord</td>
<td>9760 669-A</td>
<td>With M8 terminal. For assembly and disassembly of the draw rod.</td>
</tr>
<tr>
<td>Torque wrench key for hex socket screws, 16 mm (M10) and 13 mm (M8), torque 20 to 40 Nm.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wrench for hex socket screws 45 mm or adjustable wrench for 45 mm bolts or larger.</td>
<td>-</td>
<td>For the test tap cover.</td>
</tr>
<tr>
<td>Shackles</td>
<td>-</td>
<td>To fit Ø 28 mm holes, for connection of the soft lifting slings to the bushing flange.</td>
</tr>
<tr>
<td>Hydraulic jack</td>
<td>PDV2330</td>
<td>For removal, and installation of the bottom contact. Draw-rod system.</td>
</tr>
<tr>
<td>Box spanner</td>
<td>9760 669-B</td>
<td>For removal, and installation of the bottom contact. Draw-rod system.</td>
</tr>
<tr>
<td>Tackle</td>
<td>-</td>
<td>For installation of the bushing at a specific angle.</td>
</tr>
</tbody>
</table>

### 4.2 Consumables

<table>
<thead>
<tr>
<th>Item</th>
<th>Brand</th>
<th>Part number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil based Vaseline</td>
<td>Fuchs</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>1171 4014-407</td>
<td>Lubricates and protects metals against corrosion. Protects rubber. Does not react with transformer oil.</td>
</tr>
<tr>
<td>Molykote Multilub</td>
<td>Dow Corning</td>
<td>1236 0011-127</td>
<td>For lubrication of draw-rod threads and bolts on the outer terminal.</td>
</tr>
<tr>
<td>Thread-locking fluid grade 42</td>
<td>-</td>
<td>-</td>
<td>High strength thread-locking fluid, permanent locking.</td>
</tr>
<tr>
<td>Thread-locking activator grade 47</td>
<td>-</td>
<td>-</td>
<td>Activator for thread-locking fluid grade 42.</td>
</tr>
</tbody>
</table>
4.3 Preparations

4.3.1 Lifting the bushing

Overview

1. Lifting tool
2. Soft bedding, e.g. rubber mat or woodboard
3. Shackle

Procedure

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

2. Loosen the M8 bolts (1).

   NOTE!
   It is not necessary to remove the M8 bolts.
3. Remove the M10 bolts (6) and washers (7), and then remove the outer terminal (6).

**NOTE!**
Keep the outer terminal (5), washers (7) and bolts (6), they will be used again.

4. Install the lifting tool (1), the M10 bolts (6) and the washers (7).
   - For GOE 250 to 950: align the side of the lifting tool with the oil-level glasses (25).
   - For GOE 1050 to 2550: align the side of the lifting tool with the oil-level gauge (26).

**NOTE!**
The lifting tool is thinner than the outer terminal, use stacks of washers or shorter bolts to correctly install the lifting tool.

5. Attach soft lifting slings (8) from the lifting holes through the lifting tool to the crane hook.

**NOTE!**
The diameter of the holes for the lifting-slings in the lifting tool is Ø50 mm.
6. For installation at a specific angle: attach soft lifting slings with a shackle (9) from the flange to the crane hook.

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

8. Carefully lift the bushing.

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

9. Adjust the shackle (9) until the bushing flange has the same angle as the transformer flange.

End of instruction

4.3.2 Oil-filling of the bushing for horizontal installation

Overview

- This procedure applies to bushings that will be oil-filled with an atmospheric process.
- This procedure does NOT apply when the bushing will be oil-filled with the vacuum process, refer to *Horizontal installation of the bushing on the transformer*, page 24.

This procedure must be done immediately before installation of the bushing on the transformer, because there is no expansion space for the oil after this procedure is completed. Thus, changes in the ambient temperature will cause the oil to expand or contract, this will cause damage to the seals in the bushing.

**CAUTION!**
Do not leave the bushing fully filled with oil.

Installation must be done immediately after the bushing is sealed. If not, changes in the ambient temperature will cause damage to the seals in the bushing.
Procedure

1. Install the lifting-tool:
   1. Remove the bolts (6) and washers (7).
   2. Install the lifting tool (1), and align the side of the lifting tool with the oil-level glasses (25).
   3. Install he bolts (6) and washers (7).

2. Lift the bushing to the vertical position.

3. Remove one of the oil-plugs (9).

4. Add clean and dry transformer oil until the bushing is completely filled.
   
   **CAUTION!**
   Make sure that the bushing is completely full of transformer oil. Air left in the bushing can cause damage.

5. Install the oil-plug (9).

6. Lower the bushing to the horizontal position.

7. Install the bushing in the transformer immediately, refer to *Horizontal installation of the bushing on the transformer*, page 24.
   
   **CAUTION!**
   Do not leave the bushing fully filled with oil.
   
   Installation must be done immediately after the bushing is sealed. If not, changes in the ambient temperature will cause damage to the seals in the bushing.

End of instruction
4.4 Horizontal installation of the bushing on the transformer

Overview

The bushing is installed without removal of the bottom contact.

Procedure

1. Install the springs (15), the guiding sleeves (16), the pressing ring (17), and the hex screws (18) to the bottom contact.

2. Remove the covering plate (1).
3. Install the nuts and washers. Tighten the nuts in a crosswise sequence.

**CAUTION!**
Make sure that the nuts are tightened evenly.
First tighten all nuts to half the torque, then to the full torque.

4. Remove the lifting gear (1):
   1. Remove the long bolts (6), washers (7) and lifting gear (1).
   2. Install the original bolts (6) and washers (7).

**NOTE!**
The lifting gear uses longer bolts (6), use the original bolts (6) to attach the outer terminal.

5. Put the winding cables through the end-shield.

6. Install the winding cables to the bottom contact.

**CAUTION!**
Make sure that there is no tension in the winding cables. Tension in the winding cables will cause damage to the bottom contact.
7. Install the end shield:
   1. Push the end shield carefully against the pressing ring (17).
   2. Turn the end shield approximately 20°, to its locked position.

4.5 Installation with draw lead

4.5.1 Calculation of the length of the draw lead

Overview

Because of the tolerances in the length of the porcelain, a nominal length for the draw lead can not be given. The actual distance between the inner terminal and the bottom of the bushing must be calculated.

Procedure

1. Measure the length (L2).
2. Subtract 350 mm from the L2 measurement.
L2 - 350 = draw lead length

⚠️ CAUTION!
Make sure that the draw lead is sufficiently long.

End of instruction

4.5.2 Installation with draw lead

Overview

1. Bushing
2. Inner terminal
3. Draw lead
4. Pull-through cord
Procedure

1. 1. Remove the inner terminal from the bushing.
    2. Remove the nut (19) and washers.

2. Solder the draw lead (2) from the transformer windings to the inner terminal (1).

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

4. Install the springs (15), the guiding sleeves (16), the pressing ring (17), and the hex screws (18) to the bottom end of the bushing.

   Torque

   40 Nm
5. Install the end shield:
   1. Push the end shield carefully against the pressing ring (17), until the hex screw heads come through the holes in the end shield.
   2. Turn the end shield clockwise approximately 20°, to its locked position.

6. Put the washers and the nut (19) on the pull-through cord.

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

7. Lower the pull-through cord (10) through the bushing.
8. Apply Molykote Multilub to the pull-through cord (10), and attach it to the inner terminal (7).

**NOTE!**
The terminal (7) has M8 threads.

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

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

**CAUTION!**
Make sure that the draw lead is entering the bushing correctly. Monitor the draw lead through the inspection openings on 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.

10. If necessary, adjust the length of the inner terminal:

1. Lift the bushing from the transformer and lower the inner terminal with the pull-through cord.
2. Remove the bolts (15).
3. Move the lower part (14).
4. Apply Molykote Multilub to the threads of the bolts (15), and install the bolts (15).

**CAUTION!**
Make sure that there is no tension in the stranded cable, or too much slack.

**NOTE!**
The lower part of the inner terminal can be moved in steps of 30 mm.

**Torque**
37.5 Nm
11. If the bushing is installed in a non vertical position:
   - For GOE 250 to 950: the sight glasses (25) must be perpendicular to the angle of the bushing.
   - For GOE 1050 to 2600: the oil-gauge (26) must point down.

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

   **CAUTION!**
   Make sure that the nuts are tightened evenly.
   First tighten all nuts to half the torque, then to the full torque.

13. Install the inner terminal:
   1. Apply Molykote Multilub on the threads of the nut (19).
   2. Install the washers and the nut (19).
   3. Remove the pull-through cord.
   4. Tighten the nut (19).

   **NOTE!**
   The guide pins (23) fit the holes in the top tube.
14. Remove the M10 bolts (6), the washers (7), and the lifting tool (1).

15. Continue with Installation of the outer terminal, page 58.

End of instruction

4.6 Installation with draw rod at transformer factory

4.6.1 Removal of the lower draw rod with bottom contact from the bushing

Overview

The bottom contact is usually installed in the bushing when it is delivered from ABB, the first step at the transformer factory is thus to remove it.

1 Upper draw rod
2 Lower draw rod with bottom contact
3 Bottom contact
4 Bushing
Procedure

1. Install the shaft (16) on the draw rod (1), and put the box-spanner (12) on the shaft (16).

2. Make sure that more than 10 mm of the threads on the upper draw rod (1) are used.

3. Put the hydraulic jack (8) on the shaft (16), and install the nut (17) and washer but do not tighten it.

   **NOTE!**
   The hydraulic jack must be in the middle of its stroke. If not, the tension of the draw rod cannot be released when the draw rod nut is loosened.
4. Loosen the draw rod nut (10):
   1. Pull the draw rod with 40 kN.
   2. Carefully increase the force until you can loosen the draw rod nut with your hand.
      If 45 kN is reached, and the draw rod nut is not loose, turn the box-spanner with a wrench.

   Refer to the instructions for the hydraulic jack.

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

   **CAUTION!**
   Do not remove the compensation device.

   **NOTE!**
   The draw rod is installed with a tension of 40 kN.

5. Loosen the nut (17).

6. Turn the shaft (16) counter clockwise to remove the shaft-socket from the upper draw rod (1).

7. Remove the hydraulic jack (8) from the bushing.
8. Apply Molykote Multilub to the threads on the pull-through cord (12), then connect it to the upper draw rod.

   **NOTE!**
   The terminal on the pull-through cord (12) has M8 threads.

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

9. Remove the draw rod nut (10).

   **NOTE!**
   The draw rod will fall out of the bushing if it is not in the horizontal position.

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

    **NOTE!**
    The upper thread (7) is locked with thread-locking fluid grade 42.

    **NOTE!**
    As standard the thread joint (20) between the draw rod and the bottom contact is locked with thread-locking fluid grade 42.
    The guiding cone (21) is loose.

11. Carefully look for damage at the bottom end of the bushing, and the inside of the center hole.

    **End of instruction**
4.6.2 Installation of the small bottom contact in the transformer

Overview

1. Small bottom contact

Procedure

1. Install the springs (15), the guiding sleeves (16), the pressing ring (17), and the hex screws (18) to the bottom end of the bushing.

**NOTE!**
The pressing ring (17) cannot be installed to the small bottom contact.

Torque
40 Nm
2. Put the winding cables through the end-shield.

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

   **Torque**
   68 ±6 Nm

4. Lift the bushing above the opening in the transformer.

5. Continue with *Installation of the bushing on the transformer; page 40.*

   End of instruction
4.6.3 Installation of the large bottom contact in the transformer

Overview

The end-shield can be installed to both the bottom contact, and the bottom nut of the bushing. This procedure describes installation on the bottom contact, for installation on the bottom nut, refer to Installation of the small bottom contact in the transformer, page 36.

Procedure

1. Install the springs (15), the guiding sleeves (16), the pressing ring (17), and the hex screws (18) to the top of the bottom contact.

Torque

40 Nm
2. Install the winding cables to the bottom contact.

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

3. Install the end shield:
   1. Push the end shield carefully against the pressing ring (17), until the hex screw heads come through the holes in the end shield.
   2. Turn the end shield approximately 20°, to its locked position.

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

End of instruction
4.6.4 Installation of the bushing on the transformer

Overview

It is important to install the draw-rod correctly, thus the ends of the draw-rod parts must make contact at (9).

![Diagram of the bushing connection]

CAUTION!

Do not disassemble the joints (1), these are correctly assembled and locked with tread-locking fluid by ABB.

Procedure

1. Connect the upper draw-rod (1) to the lower draw-rod (4).
2. Make sure that the joint is correctly threaded:
   1. Calculate the nominal distance:
      \[ H = L5 - 25 \text{ mm} (\pm 2 \text{ mm}) \]
      Refer to the rating plate for the distance L5.
   2. Measure the distance H and compare it to the nominal distance H.
   3. Record the measured distance H and keep it with the substation documentation.

   **NOTE!**
   When the joint is correctly threaded, 2 threads on the upper (7) and lower (8) threads are visible.

3. If the bushing has the small bottom contact, then install the end shield:
   1. Push the end shield carefully against the pressing ring (17), until the hex screw heads comes through the holes in the end shield.
   2. Turn the end shield approximately 20°, to its locked position.

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

   **CAUTION!**
   Do not damage 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. If the bushing is installed in a non vertical position:
   - For GOE 250 to 950: the sight glasses (25) must be perpendicular to the angle of the bushing.
   - For GOE 1050 to 2600: the oil-guage (26) must point down.

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

7. Install the draw-rod nut (10):
   1. Apply a generous quantity of Molykote Multilub to the nut (10), and the threads of the draw rod.
   2. Install the washer (11) and nut (10) on the draw rod, tighten with your fingers.
   3. Remove excess Molykote Multilub with a rag.

   **CAUTION!**
   If the nut (10) is not lubricated correctly, it will not be tighten to the correct torque. This can cause the bushing to fail.

   **CAUTION!**
   Make sure that the centering ring (28) is in position. It is necessary for the correct installation of the draw rod.
8. Tighten the draw-rods nut (10).

9. Remove the pull-through cord (12).

10. Remove the bolts (6), the washers (7) and the lifting gear (1).

11. Tighten the draw-rods nut, refer to Hydraulic tightening of the draw-rods nut, page 51, or Manual tightening of the draw-rods nut, page 55.

End of instruction
4.7 Installation with draw rod at site

4.7.1 Preparations at site

Overview

This procedure is only applicable if the lower draw rod with the bottom contact (5) is installed in the transformer.

Procedure

1. Loosen the M8 bolts (1).
2. Remove the M10 bolts (6), and then remove the outer terminal (5).

3. Install the lifting tool (1), the M10 bolts (6) and the washers (7).
   - For GOE 250 to 950: align the side of the lifting tool with the oil-level sight glasses (25).
   - For GOE 1050 to 2550: align the side of the lifting tool with the oil-level gauge (26).

4. Put the pull-through cord (12) through the box-spanner (13).

Torque
40 ±4 Nm
5. Apply Molykote Multilube to the thread on the pull-through cord (12), and then connect it to the draw rod.

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

6. Remove the M16 nut (10).

7. With a soft cloth, carefully clean the bottom end of the bushing, and the inside of the center hole. Look for damage.

8. Pull down the upper draw rod (1) from the bottom end of the bushing.
9. Remove the transport cover (13) from the transformer (11) and the lower draw rod (4).

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

4.7.2 Installation of the bushing on the transformer at site

Procedure

1. Apply locking fluid on the threads (8) on the lower draw-rod (4).
   • If the bottom contact is removed from the lower draw-rod (4): apply locking fluid on the threads (20).
     Make sure that the guiding cone (21) is in position.

   **CAUTION!**
   Make sure that all joints in the draw rod are locked with thread-locking fluid.

   **NOTE!**
   Use thread-locking fluid grade 42 and activator grade 47.
2. Connect the upper draw-rod (1) to the lower draw-rod (4).

3. Make sure that the joint is correctly threaded:
   1. Measure the distance H and compare it to the nominal distance H.
   2. Calculate the nominal distance: 
      \[ H = L5 - 25 \text{ mm}(\pm 2 \text{ mm}) \]
      Refer to the rating plate for the distance L5.

   **NOTE!**
   When the joint is correctly threaded, 2 threads on the upper (7) and lower (8) threads are visible.

4. If the bushing has the small bottom contact, then install the end shield:
   1. Push the end shield carefully against the pressing ring (17), until the hex screw heads comes through the holes in the end shield.
   2. Turn the end shield approximately 20°, to its locked position.
5. Hold the pull-through cord (12) in tension, while lowering the bushing onto the transformer.

**CAUTION!**
Do not damage 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.

6. If the bushing is installed in a non vertical position:

- For GOE 250 to 950: the sight glasses (25) must be perpendicular to the angle of the bushing.
- For GOE 1050 to 2600: the oil-guage (26) must point down.

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

**CAUTION!**
Make sure that the nuts are tightened evenly.
First tighten all nuts to half the torque, then to the full torque.

**Torque**
Please refer to the transformer documentation.
8. Install the draw-rod nut (10):
   1. Apply a generous quantity of Molykote Multilub to the nut (10), and the threads of the draw rod.
   2. Install the washer (11) and nut (10) on the draw rod, tighten with your fingers.
   3. Remove excess Molykote Multilub with a rag.

   **CAUTION!**
   If the nut (10) is not lubricated correctly, it will not be tightened to the correct torque. This can cause the bushing to fail.

   **CAUTION!**
   Make sure that the centering ring (28) is in position. It is necessary for the correct installation of the draw rod.

9. Tighten the draw-rod nut (10).

10. Remove the bolts (6), washers (7) and lifting gear (1).

11. Remove the pull-through cord (12).
12. Tighten the draw-rod nut, refer to *Hydraulic tightening of the draw-rod nut, page 51*, or *Manual tightening of the draw-rod nut, page 55*.

End of instruction

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

#### Overview

![Diagram of hydraulic jack and draw-rod nut](image)

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Hydraulic jack</td>
</tr>
<tr>
<td>10</td>
<td>Draw-rod nut</td>
</tr>
</tbody>
</table>

#### Procedure

1. Measure the distance (a).

**NOTE!**

The bushing is delivered with an information sheet that specifies the draw-rod extension (b-a). These values are measured when the bushing is manufactured, and are unique to every unit.
2. Install the shaft (16) on the draw rod (1), and put the box-spanner (12) on the shaft (16).

3. Make sure that more than 10 mm of the threads on the upper draw rod (1) are used.

4. Put the hydraulic jack (8) on the shaft (16), and install the nut (17) but do not tighten it.

5. Pull the draw rod with 40 kN.

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

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

6. Turn the nut on the upper draw rod (1) with the box-spanner, tighten with your hand.
7. Loosen the nut (17).

8. Turn the shaft (16) counter clockwise to remove the shaft-socket from the upper draw rod (1).

9. Remove the hydraulic jack (8) from the bushing.
10. Make sure that the draw-rod extension is within the tolerances:
   1. Measure the distance (b).
   2. Calculate the extension of the draw rod: (b) minus (a).
   3. Compare the calculated draw-rod extension to the measured extension, refer to the table.

**NOTE!**
Please contact ABB for special bushings.

<table>
<thead>
<tr>
<th>Type</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOE 250 - 210</td>
<td>3.5 mm ±1.0</td>
</tr>
<tr>
<td>GOE 380 - 300</td>
<td>3.5 mm ±1.0</td>
</tr>
<tr>
<td>GOE 650 - 500</td>
<td>5.0 mm ±1.0</td>
</tr>
<tr>
<td>GOE 950 - 650</td>
<td>7.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1050 - 750</td>
<td>9.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1175 - 850</td>
<td>9.5 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1300 - 1050</td>
<td>12.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1425 - 1150</td>
<td>12.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1550 - 1175</td>
<td>15.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1675 - 1300</td>
<td>15.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1800 - 1360</td>
<td>15.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 2550 - 1600</td>
<td>18.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 2550 - 1675</td>
<td>18.0 mm ±2.0</td>
</tr>
</tbody>
</table>

11. Measure the value (c), record it for future reference.
    Keep the document with the substation documentation.

End of instruction
4.9 Manual tightening of the draw-rod nut

Overview

This procedure requires the draw-rod nut, washer and threads of the draw rod to be correctly lubricated. The draw rod will not get the correct tension if the fasteners are not correctly lubricated, this can cause the bushing to fail. If possible, ABB recommends that the draw rod is hydraulically tightened, refer to Hydraulic tightening of the draw-rod nut, page 51.

Procedure

1. Make sure that the draw-rod nut, and threads of the draw rod are correctly lubricated, and that the draw-rod nut is tightened to 10 Nm.

2. Measure the distance (a).
3. Turn the nut clockwise until you get the correct extension (b).
Distance (b) = (a) + extension, refer to the table.

CAUTION!
Make sure that you do not overtighten the nut. Use a torque wrench set to 140 Nm.

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOE 250 - 210</td>
<td>3.5 mm ±1.0</td>
</tr>
<tr>
<td>GOE 380 - 300</td>
<td>3.5 mm ±1.0</td>
</tr>
<tr>
<td>GOE 650 - 500</td>
<td>5.0 mm ±1.0</td>
</tr>
<tr>
<td>GOE 950 - 650</td>
<td>7.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1050 - 750</td>
<td>9.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1175 - 850</td>
<td>9.5 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1300 - 1050</td>
<td>12.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1425 - 1150</td>
<td>12.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1550 - 1175</td>
<td>15.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1675 - 1300</td>
<td>15.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 1800 - 1360</td>
<td>15.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 2550 - 1600</td>
<td>18.0 mm ±2.0</td>
</tr>
<tr>
<td>GOE 2550 - 1675</td>
<td>18.0 mm ±2.0</td>
</tr>
</tbody>
</table>

4. Make sure with a torque wrench that the nut is tightened with a torque of more than 70 Nm and less than 140 Nm.

5. Measure the value (c), record it for future reference.
Keep the document with the substation documentation.

End of instruction
4.10 Oil-filling

Overview

Start this procedure when the transformer oil has reached the bottom of the bushing.

• This procedure is applicable to bushings that are installed in a position that is 0° – 60° from vertical.
• This procedure is NOT applicable if the transformer is oil-filled with the vacuum process.

Procedure

1. Make sure that the transformer oil-level is maximum 30 mm from the flange.

⚠️ CAUTION!
A lower oil-level will decrease the cooling of the bushing, and can cause spontaneous flashover.
2. Wait until the oil-level \( h \) in the center-tube has risen to the same height as the oil-level in the transformers oil-conservator.
   - If the top of the bushing is lower than the transformers oil-conservator, wait until oil flows out from top of the bushing.

**NOTE!**
Air is soluble in transformer oil, thus as much as possible must be released from the bushing center-tube.

---

### 4.11 Installation of the outer terminal

**Procedure**

1. Prepare the contact surface and gasket surface:
   1. Carefully clean the contact surface and gasket surface with a soft cloth.
   2. Apply Vaseline to the contact surface.
   3. Apply Mobilgrease 28 to the gasket surface.

**CAUTION!**
Do not use a wire brush on the zinc coating (9).
2. Prepare the contact surface, gasket surface and O-ring:
   1. Carefully clean the contact surface and gasket surface with a soft cloth.
   2. Apply Vaseline to the contact surface.
   3. Apply Mobilgrease 28 to the gasket surface and O-ring (3).

   **CAUTION!**
   Do not use a wire brush on aluminium outer terminals. A wire brush can make scratches in the zinc coating (9).

   **NOTE!**
   Or use lubricants with equal properties to Vaseline and Mobilgrease 28.

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

3. Assemble the tightening ring (4), the O-ring (3), and the outer terminal (5).

4. Apply Molykote Multilub to the threads of the M8 bolts (1).

5. Install the M8 bolts (1), and the spring washers (2).

   **Torque**
   Tighten with your fingers.
6. Apply Molykote Multilub to the M10 bolts (6).

7. Install the M10 bolts (6) and plain washers (7).

8. Tighten the M10 bolts (6) in a crosswise sequence.

   **CAUTION!**
   Make sure that the outer terminal moves straight down. Turn each bolt a little, and then the next bolt, until all bolts can be tightened to the correct torque.

9. Tighten the M8 bolts (1).
   Tighten the bolts in a crosswise sequence.

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

   End of instruction
4.12 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**
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, or in an inclined position of 7°, 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. 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 manufactures 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 test 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 Tightness test of bushing outer terminal

Overview

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

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

Example procedure

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

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

2. Increase the oil level to just below the bushing flange, to raise the pressure in the center tube.
3. Find leaking gas with gas detector (sniffer) near the gasket.

5.2.4 Measurement of capacitance and dissipation factor

Overview

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

- $C_1$ is the capacitance between the test tap and the outer terminal.
- $C_2$ is the capacitance between the test tap and ground.

Nominal capacitance

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Space for CT = 305 mm</th>
<th>Space for CT 605 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$C_1$</td>
<td>$C_2^*$</td>
</tr>
<tr>
<td>GOE 250-210</td>
<td>448</td>
<td>290</td>
</tr>
<tr>
<td>GOE 380-300</td>
<td>448</td>
<td>290</td>
</tr>
<tr>
<td>GOE 650-500</td>
<td>392</td>
<td>300</td>
</tr>
<tr>
<td>GOE 950-650</td>
<td>377</td>
<td>658</td>
</tr>
<tr>
<td>GOE 1050-750</td>
<td>383</td>
<td>390</td>
</tr>
<tr>
<td>GOE 1175-850</td>
<td>420</td>
<td>480</td>
</tr>
<tr>
<td>GOE 1300-1050</td>
<td>536</td>
<td>640</td>
</tr>
<tr>
<td>GOE 1425-1150</td>
<td>536</td>
<td>640</td>
</tr>
<tr>
<td>GOE 1550-1175</td>
<td>500</td>
<td>700</td>
</tr>
<tr>
<td>GOE 1675-1300</td>
<td>500</td>
<td>700</td>
</tr>
<tr>
<td>GOE 1800-1360</td>
<td>500</td>
<td>700</td>
</tr>
<tr>
<td>GOE 2550-1600</td>
<td>558</td>
<td>4610</td>
</tr>
<tr>
<td>Type</td>
<td>Space for CT = 605 mm</td>
<td>Space for CT = 905 mm</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td></td>
<td>$C_1$</td>
<td>$C_2^*$</td>
</tr>
<tr>
<td>GOE 2550-1675</td>
<td>610</td>
<td>5000</td>
</tr>
</tbody>
</table>

* Reference values from ABB Components.

**Dissipation factor, tan δ**

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

<table>
<thead>
<tr>
<th>Bushing body temperature °C</th>
<th>Correction factor to 20 °C (IEC)</th>
</tr>
</thead>
<tbody>
<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>0.10</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>
</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>2769 522-M</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 table for the nominal capacitance \( C_1 \), Nominal capacitance, page 65.

6. Measure the capacitance \( C_2 \) between the stud (1) and the flange (3).
   
   • 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
5.2.5 Measurement of through-resistance

Overview

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

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

The total through-resistance is the sum of the transformer winding, lead resistance, the bushing conductor, and contact resistance. The additional resistance from the bushing conductor should not be more than 150 μΩ. Because the through-resistance of the HV winding of a typical power transformer is in the order of 0.1 to 1 Ω, this is a very rough method that can only be used to detect very large faults in the current path, such as open circuits.

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

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

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 shed is exposed to very high pollution, it can be necessary to clean the surface. Remove the pollution with a moist cloth, or a low pressure water jet. 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 joints in the insulator shed, and between the insulator shed and metal parts.
Measurement of capacitance and dissipation factor

Please refer to Measurement of capacitance and dissipation factor, page 65.

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.

Checking of oil-level

The oil-level at normal and high temperatures, must always be above the red area on the oil-level indicator.

If the oil-level is in the red area (10), clean and dry transformer oil must be added. For the correct oil-level, please contact ABB. Adding oil is only allowed when the temperature of the bushing is between +5 °C and +35 °C.

⚠️ CAUTION!
Be careful when the oil plug is removed, contamination can enter the bushing.

Use a new gasket with the oil plug (9). Tighten the oil plug (9) to 20 Nm.

⚠️ CAUTION!
Make sure that the oil plug is correctly installed, and that there is no leakage.
Taking oil-samples

Taking oil samples is generally not recommended.
Take an oil sample only if a problem is known, for example a high power factor over C₁, or visible oil leakage. Please refer to product information 2750 515-142 "Bushing diagnostics and conditioning".

Take the oil sample from the oil valve (8) in the flange, and close the oil valve (8).

⚠️ **CAUTION!**
Make sure that the oil valve (8) is correctly closed.

ℹ️ **NOTE!**
It is generally not necessary to add oil after an oil sample is taken. But it can be necessary to add oil when many oil samples have been taken.
7 Re-packing

7.1 Removal of horizontally installed bushings

Overview
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, refer to Removal of the bushing from the transformer, draw rod, page 74.

2. Drain a small quantity of transfomer-oil.

3. Install the covering plate (1) and the gasket over the oil-passage.

4. Put the bushing in the vertical position.

Torque
M12 50 ±5 Nm
5. Remove the oil-plug (9).

6. Remove transformer oil until the oil-level is correct for storage.

![CAUTION!]
Make sure that the oil level is correct. If not, changes in the ambient temperature will cause damage to the seals in the bushing.

![NOTE!]
The correct oil-level is between the sight-glasses.

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

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

End of instruction

7.2 Removal of the bushing from the transformer, draw rod

Procedure

1. Install the lifting tool, refer to *Lifting the bushing*, page 20.
2. Put the pull-through cord (12) through the box-spanner (13).

**NOTE!**
The terminal on the pull-through cord (12) has M8 threads.

**NOTE!**
ABB Components recommends that the hydraulic jack is used for the removal of the bottom contact, refer to *Removal of the lower draw rod with bottom contact from the bushing*, page 32 steps 1 through 8.

3. Apply Molykote Multilub to the thread on the pull-through cord (12), then connect it to the draw rod.

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

4. Remove the M16 nut (10) on the draw rod with the box spanner (13).
5. Remove the nuts and washers.

6. Lift the bushing from the transformer.

**CAUTION!**
Do not damage the stud bolts, there is a risk of metal falling into the transformer.

7. Disassemble the draw rod at the lower joint (8).
Use the key grip on the lower draw rod.

**DANGER!**
Make sure that the upper draw rod does not fall down when the lower joint (8) is disassembled.

**NOTE!**
The upper thread (7) is locked with thread-locking fluid grade 42.

**NOTE!**
The bushing can have an optional joint, or the bottom contact unlocked (20), refer to the specifications for your bushing.
The guiding cone (21) is loose.
8. Pull up the draw rod, and install the washer (11) and nut (10).

**CAUTION!**
Make sure that the centering ring (28) is in position, it is necessary for the correct installation of the draw rod.

9. Remove the pull-through cord (12).

10. Lower the bushing to the floor.

**CAUTION!**
Make sure that there is soft bedding, or support blocks on the floor.

11. Install the lower draw rod (4) in the transport cover (13).

12. Install the transport cover (13) on the transformer turret (11).

*End of instruction*
7.3 Re-packing of the bushing

Overview

Procedure

1. Put plastic wrap on the draw-rod, and attach it to the transport box.

   CAUTION!
   Do not put the draw rod into the bushing, the threads on the draw rod will scratch the inside of the center-tube conductor.

2. Lift the bushing. Refer to Lifting the bushing out of the transport box, page 17.

3. Lower the bushing into the transport box.

   CAUTION!
   Make sure that there is soft bedding 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 16 and Transportation, page 15.

End of instruction
8 Spare parts and special tools

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.

8.2 Spare parts

Cover

For the test tap.

<table>
<thead>
<tr>
<th>Position</th>
<th>Part</th>
<th>Article number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cover</td>
<td>1ZSC004579-AAA</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>O-ring</td>
<td>1ZSC00442-CAK</td>
<td>-</td>
</tr>
</tbody>
</table>
### Oil-plug 2522 731-A

<table>
<thead>
<tr>
<th>Position</th>
<th>Part</th>
<th>Article number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oil-plug</td>
<td>2121 738-18</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Gasket</td>
<td>1ZSC001591-AAC</td>
<td>-</td>
</tr>
</tbody>
</table>

![Diagram of Oil-plug 2522 731-A](image)

**Cover for oil-plug 2522 731-A**

For new design of the top chamber.

This cover gives protection to the oil-plug 2522 731-A.

<table>
<thead>
<tr>
<th>Position</th>
<th>Part</th>
<th>Article number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cover</td>
<td>2522 732-42</td>
<td>M24</td>
</tr>
<tr>
<td>2</td>
<td>Gasket</td>
<td>2152 795-67</td>
<td>-</td>
</tr>
</tbody>
</table>

![Diagram of Cover for oil-plug 2522 731-A](image)
8.3 Special tools

Lifting tool

<table>
<thead>
<tr>
<th>Part</th>
<th>Article number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifting tool</td>
<td>9760 668-A</td>
<td>-</td>
</tr>
</tbody>
</table>

Pull-through cord

<table>
<thead>
<tr>
<th>Part</th>
<th>Article number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pull-through cord</td>
<td>9760 669-A</td>
<td>With M8-terminal.</td>
</tr>
</tbody>
</table>
### Hydraulic jack

<table>
<thead>
<tr>
<th>Part</th>
<th>Article number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic jack</td>
<td>PDV2330</td>
<td>-</td>
</tr>
</tbody>
</table>

![Hydraulic jack](image1)

### Box-spanner

<table>
<thead>
<tr>
<th>Part</th>
<th>Article number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box-spanner</td>
<td>9760 669-B</td>
<td>-</td>
</tr>
</tbody>
</table>

![Box-spanner](image2)
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.

DANGER!

Be careful when dissembling the bushing.

There is a large quantity of mechanical energy stored in the bushing from its assembly, disassembly of the bushing can cause it to break with explosive force.

The bushing has these parts and materials

- The conductor is made of copper or low-alloy aluminum.
- The terminals are made of copper or low-alloy aluminum.
  The terminals can be plated with silver, tin, gold or nickel, with a thickness up to 20 μm.
- Transformer oil, refer to IEC 60296, class 2.
- The condenser core is made of paper and 1 % aluminum foil, impregnated with transformer oil.
- The top housing, top end nut, test tap and flexible connection are made of aluminum alloys.
- The flanges are made of aluminum.
- The press ring for the oil-level sight glass is made of plated brass.
  The oil-level sight glass is made of glass.
- The insulators are made of quartz-silicate or alumino-silicate based 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 plant, or sorted into different component materials for correct processing.
Metals

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

The recycling of precious metals is particularly important. Metals such as copper and silver are expensive, and are only present in small quantities in the earth's crust. Copper is primarily used in current conductors, contacts and cables. Some contacts are silver plated. Fumes from some metals can cause environmental damage, this applies to zinc and nickel, which are used sparingly as surface coatings.

Plastics

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

Oils and greases

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

Rubber

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

Rubber is used in seals and gaskets.

Other materials

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

10.1 Summary

- Markings: Conforming to IEC/IEEE.
- Bushing diagnostics and conditioning, 2750 515-142.
- Test adapter, Installation and maintenance guide, 1ZSC000563-ACD.
- Transformer oil, IEC 60296, class 2.