Vacuum on-load tap-changers, type VUBB
Installation guide
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1. Safety

1.1 General
This installation guide should be read and understood before any work is begun, and the procedures in this document should be followed at all times.

1.2 Safety warnings
The following warnings and notes are used in the manual:

WARNING
WARNING indicates an imminently hazardous situation, which if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

WARNING also indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION
CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert of unsafe practices.

CAUTION may also indicate property-damage-only hazards.

INFO
INFO provides additional information to assist in carrying out the work described and to provide trouble-free operation.

1.3 Safety precautions
1.3.1 Personal safety
Unused transformer oil is slightly harmful. Fumes from unused warm oil may irritate the respiratory organs and eyes. After long and repeated contact with transformer oil, the skin becomes excessively dry. Avoid contact with the oil as much as possible and use oil-tight protective gloves when handling.

Used tap-changer oil contains harmful substances. Fumes are irritating to the respiratory organs and eyes and can very easily ignite. Used transformer oil may be carcinogenic.

1.3.2 Environmental safety
Collect used oil in oil drums.

Waste oil should be removed using an absorbing agent. Treat it as environmentally hazardous waste.

1.3.3 First aid
Skin contact
1. Wash the body part that has been exposed to the oil.
2. Rub moisturizer into the skin to counteract drying.

In the eyes
Rinse the eyes with clean water.

Swallowing

WARNING
Avoid vomiting.

1. Drink water or milk.
2. Call a doctor.

1.3.4 In the event of fire
In the event of fire, powder, foam or carbon acid are used as extinguishing agents.
2. Introduction

2.1 General
The on-load tap-changers manufactured by ABB have been developed over a period of many years to provide maximum reliability. In most applications, the simple and robust design provides a service life equal to the service life of the transformer.

Minimum maintenance is required for trouble-free operation. Maintenance is normally not required on the parts situated in the oil of the transformer tank. The only parts requiring maintenance are the vacuum interrupters (which may require replacement), the insulating oil and the motor-drive mechanism.

The design allows easy access to all parts, making inspection and maintenance quick and simple. See Fig. 1.

The VUBB tap-changer is located in the transformer tank. See Fig. 2. The motor-drive mechanism is attached to the transformer tank and connected to the tap-changer by means of drive shafts and bevel gears. (The motor-drive mechanism is described in a separate manual.)

---

**WARNING**

Small amounts of explosive gases are constantly discharged from the breathing devices (dehydrating breather or one-way breather). Make sure that no open fires, hot surfaces or sparks are present in the immediate surroundings of the breathing devices.

Personnel operating and inspecting the tap-changer must have good knowledge of the apparatus and be aware of the risks pointed out in this manual.

Personnel making electrical connections in the motor-drive mechanism must be certified.

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**CAUTION**

After a pressure relay trip, call a ABB. The tap-changer housing must be drained and the selector switch lifted and carefully examined before the transformer is reenergized.

2.2 Functional description
The on-load tap-changer is a device for changing the tap connection of a winding while the transformer is under load. The main purpose of the device is to maintain a constant voltage output from the transformer and to compensate for variations in the load situation. The tap-changer is connected to the transformer via the tap winding. The main function is tap selection, which is accomplished by changing the number of turns on the regulating winding.

Although many different circuit solutions are available, the selected solution has been found to provide the best combination of technical performance and economy. By using auxiliary contacts in combination with vacuum interrupters, the contacts are used for carrying current and the vacuum interrupters are used for energized switching. With this solution, only two vacuum interrupters are required per phase and the voltage rating for the vacuum interrupters can be lower.

The electrical circuit principle for the VUBB is shown in the technical guide. The purpose of switching is to transfer the current flowing between one of the tap contacts and the winding, and in doing so, connect or disconnect one regulation step on the transformer.

Depending on the direction the center shaft rotates, two different contact sequences are obtained – either the main interrupter or the resistor interrupter executes breaking.
Fig. 1. VUBB overview.
Fig. 2. System overview.
3. Installation

3.1 General
The VUBB on-load tap-changer is mounted using either the cover-mounting method or the yoke-mounting method.

ABB recommends careful consideration of the following factors when installing tap-changers.

- Before installing a unit, make sure that the personnel doing the job have read and fully understood these installation instructions.
- Do not modify a unit without first consulting the manufacturer.
- Follow local and international wiring regulations at all times.

⚠️ WARNING
Before any work is carried out on the tap-changer, make sure that the transformer is disconnected and that grounding is properly executed.

⚠️ CAUTION
Sealing surfaces and gaskets must be clean and undamaged.

Diametrically opposed bolts in sealing joints must be tightened alternately several times, beginning with a low tightening torque and finally with the recommended tightening torque.

3.2 Required tools and materials
The following tools are required for the installation of the tap-changer:

- Air pump with hose, pressure gauge (0-250 kPa) and connection with internal thread R 1/8"
- Standard set of open-end wrenches (up to 18 mm)
- Standard set of sockets (up to 18 mm)
- Socket handle
- Socket extender
- Standard set of screw drivers
- Allen keys for 5- and 6-mm sockets
- Hand crank LL 117 016-M
- Dynamometric wrenches, 5-85 Nm
- Bottom valve key (supplied with the tap-changer)
- Tool for opening the oil drum
- Hack saw
- Bucket, 10 liters
- Lifting slings
- Equipment for oil filling
- Rags (lint-free) for cleaning

The following greases (ball bearing greases) or similar are required during installation:

- GULF-718 EP
- Mobil-Grease 28
- SHELL-Aero Shell Grease 22

3.3. Oil
The tap-changer contains about 300 liters of oil. The oil quality must be LC set -30° according to IEC 60296:2012.

The oil must also comply with IEC 60422:2005.

3.4 Tightening torques
The following tightening torques are recommended unless otherwise stated in this installation guide:

<table>
<thead>
<tr>
<th>Size</th>
<th>Torque (Nm)</th>
<th>±10 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>M6</td>
<td>10</td>
<td>±10 %</td>
</tr>
<tr>
<td>M8</td>
<td>24.5</td>
<td>±10 %</td>
</tr>
<tr>
<td>M10</td>
<td>49</td>
<td>±10 %</td>
</tr>
<tr>
<td>M12</td>
<td>84</td>
<td>±10 %</td>
</tr>
</tbody>
</table>
3.5 Unpacking and lifting
If the tap-changer is not to be used immediately, it can be stored according to Section 3.6.

1. Remove the packing list from the packing crate.
2. Check the list to make sure that all parts have been provided.
3. Check that the type designations and serial numbers correspond with the packing list or with the order acknowledgement.
4. Check that there is no external damage to the packing crates. If a crate is damaged, refer to the instructions in Section 3.5.1.
5. Remove the covers and the sides of the transport crates.
6. Remove all parts transported in the tap-changer crate.

When lifting the tap-changer, it is advisable to use the lifting eyes on the top section; see Fig. 3.

7. Attach the lifting chains to the lifting eyes. The angle between the lifting chains should be no more than 90°; see Fig. 4.

Fig. 3. Lifting eyes.

8. Raise the tap-changer slowly.
9. Remove any rust protection.

3.5.1 Actions when damage is discovered
If a packing crate is damaged during transport, carefully check that nothing is missing or damaged.

If damage is discovered, contact ABB and submit a damage report with photos of the damaged parts, ABB’s reference number, the tap-changer serial number and the crate number.

3.6 Temporary storage before assembly
If the tap-changer is not to be installed immediately after the delivery has been approved, it can be stored indoors in a warm and dry location, in its plastic enclosure and with the drying agent left inside until installation.
3.7 Installation in the transformer
3.7.1 Cover-mounting
1. Make sure that the drying agent is removed.
2. Fit a gasket around the opening in the transformer cover.
   See Fig. 5. (The gasket is not included in the tap-changer delivery.)

![Fig. 5. Gasket around the opening in the transformer cover.](image)

3. Place the tap-changer carefully into the hole in the transformer cover. Make sure that you do not damage the terminals.
4. Position the tap-changer for mounting pipes, the shaft system and terminals (see the transformer drawing). Make sure that the studs on the transformer cover fit the holes (14-mm diameter) on the tap-changer flange. See Fig. 6.

![Fig. 6. The studs on the transformer must fit the holes on the tap-changer flange.](image)

5. Fit a washer and an M12 nut on two of the studs (one on each side) on the top flange as shown in Fig. 7. Tighten the nuts. See Section 3.4 for tightening torque.

![Fig. 7. Fit a washer and an M12 nut on the top flange.](image)

6. Fit a washer and an M12 nut on the remaining studs (Fig. 8), and tighten the nuts with the same tightening torque as above.
7. Remove the lifting chains from the lifting eyes.

![Fig. 8. Fit washers and nuts on the remaining studs.](image)
3.7.2 Yoke-mounting
(Pre-mounting on active part of the transformer).

The top section of the tap-changer is designed to be divided into an upper and a lower flange (see Fig. 9) to fit the yoke-mount.

Before the tap-changer is lifted and attached to the transformer cover, it is positioned on a fork consisting of two beams protruding from the upper transformer yoke.

If guide pins are used on the fork, they should be insulated with bushings to prevent currents in the fork when the transformer is in operation.

Mounting of the tap-changer to the yoke-fork can be executed according to two alternatives, depending on when testing of the transformation ratio will be performed:

- Transformer ratio measurement before drying; see Section 3.7.2.1.
- Transformer ratio measurement after drying; see Section 3.7.2.2.
- Mounting on the transformer cover from the yoke; see Section 3.10.4.

Fig. 9.
1. Make sure that the drying agent is removed.
2. Fit a guide pin on each yoke-fork. See Fig. 10.

![Fig. 10. Guide pins.]

The guide pins must be insulated to prevent currents in the fork when the transformer is in operation.

3. Place the tap-changer on the yoke-fork. Make sure that the top flange of the tap-changer is level with the transformer cover by placing wooden spacers on the yoke-fork, and with the tap-changer resting on the spacers at its intermediate flange. See Fig. 11. Correctly position the tap-changer for mounting of pipes, the shaft system and terminals (see the transformer drawing).

![Fig. 11. Place wooden spacers on the yoke-fork.]

3.7.2.1 Mounting of the tap-changer when transformer ratio measurement is carried out before drying

Mounting to the yoke-fork of the transformer; see Fig. 9.

1. Mount the tap-changer on the transformer’s yoke-fork. The lifting lugs on the upper part can be used to facilitate this; see Fig. 3. Handle with care so that no damage is caused to the terminals.

Check that the tap-changer is correctly turned in relation to the transformer cover before connecting the conductors.

2. Connect the conductors according to Section 3.8.
3. Transformer ratio measurement:
   The tap-changer can be operated by turning the bevel gear shaft. Use the special hand crank, LL 117 016-M. Two clockwise turns (as viewed towards the shaft end) for raise or two turns counter-clockwise turns for lower will be equal to one switching between two taps. Check the order documents to ensure that nothing to the contrary is stated regarding the direction of rotation.

**CAUTION**

The tap-changer must be operated through the entire operating range, in both the lower and raise directions, when carrying out ratio measurement.

**CAUTION**

When operating the tap-changer without a drive system, check the designation of the end-positions on the single-phase diagram.

**CAUTION**

Monitor the voltmeter during the tap-changer operations. No rapid voltage drops may occur during operation. If such drops occur, the tap-changer is not correctly connected to the winding.
4. After measurement, the position of the tap-changer must be returned to the same position as indicated by the motor-drive mechanism. Check this through the indicator window on the top cover.

5. Remove all 12 bolts (Fig. 12) and washers in the top cover and carefully lift the cover at least 10 cm straight up before moving it in horizontally; see Fig. 13. The bevel gear and the pipe must not be damaged when lifting. If a crane is used, arrange the straps according to Fig. 4.

**CAUTION**

Be careful not to drop any screws or other parts into the tap-changer.

- Place all removed parts in a box to prevent them from falling into the tap-changer.
- Lift with caution to avoid damage to the bevel gear and the pipe.

6. Remove the upper part of the top section by removing the 12 M12 socket head cap screws on the inside; see Fig. 14. Temporarily store the flange, cover, and O-rings at a dust-free location.

7. The tap-changer and the transformer are now ready for drying. Follow the instructions in Section 3.10.

    - The gear mechanism on the gear base plate need not and shall not be removed. This is because it is attached to the lower part.
    - Spacers (wooden spacers, for example) can be placed between the yoke-fork and the lower flange. This permits the connectors to be mounted at the correct and final height. The spacers must be removed before mounting the tap-changer on the transformer cover. See Fig. 11.
3.7.2.2 Mounting of the tap-changer when transformer ratio measurement is carried out after drying

Mounting on the transformer yoke-fork. See Fig. 9.

1. Remove all 12 bolts and washers in the top cover and carefully lift the cover at least 10 cm straight up before moving it horizontally. If a crane is used, arrange the straps according to Fig. 4.

2. Remove the upper part of the top section by removing the 12 M8 socket head cap screws on the inside. Temporarily store the flange, cover, and O-rings (see Fig. 14) at a dust-free location.

---

The gear mechanism on the gear base plate need not and shall not be removed, because it is attached in the lower part.

---

3. When lifting the tap-changer onto the yoke-fork, it is advisable to use the lifting eyes on the mechanism; see Fig. 4.

---

Check that the tap-changer is correctly turned in relation to the transformer cover before connecting conductors according to Section 3.8.

---

Spacers (wooden spacers, for example) can be placed between the yoke-fork and the lower flange. In this way, the connectors can be mounted at the correct and final height. The spacers must be removed before mounting the tap-changer on the transformer cover. See Fig. 11.

---

4. The tap-changer and the transformer are now ready for drying. Follow the instructions in Section 3.10.
3.8 Conductor connections to terminals

1. Connect all conductors to the tap-changer terminals according to the connection diagram supplied with the tap-changer. Make sure to make an expansion bend on every conductor as shown in Fig. 15. All connection bolts must be carefully tightened with the torque prescribed in Section 3.4.

CAUTION

The conductors must not cause mechanical stress on the tap-changer terminals.

It is recommended that the distance between the cylinder and any conductor be at least 50 mm.

The transformer manufacturer is responsible for providing sufficient distances in the oil.

2. If shielding caps are used, attach and close them according to Figs. 16 and 17.

CAUTION

The shielding caps must not be opened and closed more than 3 times before being replaced.

Shielding caps can be bought as accessories.

If yoke-mounted:

3. Release the wooden spacers by slightly lifting the tap-changer.
4. Remove the wooden spacers from the yoke-fork.
5. Lower the tap-changer onto the yoke-fork.
3.9 Transformer ratio measurement
The next step is to carry out the transformer ratio measurement. The tap-changer can be operated by turning the bevel gear shaft.

1. Note the position of the tap-changer. To access the position indicator, remove the cover. See Fig. 18.

2. Attach the hand crank (LL 117016-M) at the spherical shaft end of the bevel gear. See Fig. 19.

3. Turn the hand crank to switch between taps:
- One turn in clockwise direction (as viewed towards the shaft end) produces a switching between two taps in a raise direction.
- One turn counter-clockwise turn produces a switching between two taps in a lower direction.

CAUTION
Before the drying process, the tap-changer may be operated as long as it is not immersed in oil.

After the drying process, the tap-changer must be filled with oil before operating.

CAUTION
Check the order documents to ensure that nothing to the contrary is stated regarding the direction of rotation. Make sure that the end-positions are not passed during ratio measurement.

4. Operate the tap-changer through the entire operating range, in both the lower and raise directions.

5. When operating the tap-changer without a drive system, check the designation of the end-positions on the single-phase diagram and watch the position indicator in the bevel gear to avoid passing the end-position.

6. After measurement, reset the tap-changer to the initial position. Refit the cover over the position indicator.
3.10 Drying
The tap-changer can be dried with the transformer according to one of the following processes:

- Vapor phase
- Alternating hot air and vacuum

⚠️ CAUTION
When drying with hot air and vacuum processing, the maximum permitted pressure difference for the tap-changer is 100 kPa at a maximum permitted temperature of 135 °C.

⚠️ CAUTION
To avoid seizing, do not operate the tap-changer, neither during the drying process nor afterwards, until it is filled with oil.

3.10.1 Before drying
1. Remove the head bolts from the bevel gear flange. See Fig. 20.
2. Remove the head bolts and the washers.
3. Remove the clamps.
4. Remove the bevel gear from the tap-changer cover.
5. Temporarily store the bevel gear at a dust-free location.

The tap-changer and the transformer are now ready for drying.

ℹ️ For vapor-phase drying, open the bottom valve.

6. Complete the drying process according to the instructions in Section 3.10.2.

3.10.2 Vapor-phase and hot-air processes
When drying, the following preparations are required:

1. Remove the screws on the top cover. See Fig. 21.
2. Remove the top cover and the O-ring beneath.

⚠️ CAUTION
Be careful not to drop any screws or other parts into the tap-changer.

Place all removed parts in a box to prevent them from falling into the tap-changer.

The tap-changer is now ready for hot-air drying.
For vapor-phase processing, continue with the following:

3. Open the bottom valve by unscrewing no more than four turns. The bottom valve can be opened using two different methods. Any of the following methods can be used:

A. Open the bottom valve by turning the external hexagon screw on the outside bottom of the housing. For external access, use a standard Allen key. See Fig. 22.

B. Open the bottom valve by unscrewing the internal hexagon screw on the inside bottom of the housing. For access, see Fig. 23. The provided bottom valve key is required for this alternative. See Fig. 24.

The tap-changer is tested in oil and small amounts of oil may be discharged from the bottom valve.

For internal access: Use the bottom valve key only (provided with the tap-changer) to operate the bottom valve.

Use of another key may damage the valve.

The tap-changer is now ready for vapor-phase drying.

**CAUTION**

When drying with hot air and vacuum processing, the maximum permitted pressure difference for the tap-changer is 100 kPa at a maximum permitted temperature of 135 °C.

3. Continue to Section 3.10.3.
3.10.3 After drying

1. Make sure that all liquid has been drained from the tap-changer housing.
2. **For vapor phase:** Close the bottom valve. Tightening torque 15 Nm.

The tap-changer is closed in two steps.

3. Refit the O-ring. Make sure that it is clean and undamaged.
4. Refit the top on the top flange.
5. Refit the screws on the top cover.
6. Tighten the screws. Tightening torque 24.5 Nm ±10 %.

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**CAUTION**

To avoid seizing, do not operate the tap-changer, neither during the drying process nor afterwards, until it is filled with oil.

After drying is completed, refit the bevel gear (see Fig. 20):

1. Make sure that the O-ring beneath the bevel gear flange is clean and undamaged.
2. Refit the bevel gear on the tap-changer cover.
3. Refit the clamps.
4. Refit the hexagon head bolts and the washers. Tighten the bolts with a tightening torque of 49 Nm ±10 %.

---

3.10.4 Mounting the tap-changer to the transformer cover

The following is done after the drying process:

1. Refit the O-ring in its groove on the intermediate flange. See Fig. 25.

---

**CAUTION**

Lift very carefully to avoid damage to the tap-changer.

2. Fit a gasket around the opening in the transformer cover. See Fig. 26. (The gasket is not included in the tap-changer delivery.)
3. Attach a lifting block or crane to the lifting bar, see Fig. 4.
4. Check when lifting that the guide pin in the lower flange clears the hole in the upper flange.

---

2. Lift the tap-changer until it touches the upper flange. Fit a washer and screw in each of the empty holes.
5. If the holes in the upper flange do not match the holes in the transformer cover, the position of the tap-changer must be adjusted, which may require careful lifting. Fit two studs (diometrical positions) in the transformer cover.

---

Fig. 25. Refit the O-ring on the intermediate flange.

Fig. 26. Gasket around opening in the transformer cover.
7. Place the top flange over the opening of the transformer cover. See Figs. 27 and 28.

8. Fit a washer and an M12 nut on two of the studs (one on each side) on the top flange as shown in Fig. 29. Tighten the nuts. See Section 3.4 for tightening torque.

9. Fit a washer and an M12 nut on the remaining studs (Fig. 30), and tighten the nuts with the same tightening torque as above.

10. Attach the lifting chains to the lifting eyes. See Fig. 31.
11. Lift the tap-changer until the intermediate flange touches the top flange. Make sure that the guide pin on the intermediate flange fits the guide hole on the bottom side of the top flange. See Fig. 32.

![Fig. 32. Fit the guide pin.](image)

**CAUTION**

Lift very carefully to avoid damaging the tap-changer.

12. Fit a flat washer, a spring washer and a screw in each of the holes inside the top flange (Fig. 33). Tighten the screws with the torque prescribed in Section 3.4.

![Fig. 33. Fitting flat washers, spring washers and screws.](image)

13. Remove the lifting eyes and the lifting chains.

**CAUTION**

Before replacing the top cover, make sure that no foreign objects remain inside the tap-changer.

14. Lower the top cover straight down against the top flange, and carefully refit the cover. Make sure to lower the cover straight down the last 10 centimeters above the top flange; see Fig. 34. Make sure that the guide pin on the top flange fits the guide hole on the bottom side of the cover; see Fig. 35.

![Fig. 34. Procedure for lowering the cover.](image)

![Fig. 35. The guide pin on the top flange must fit the guide hole on the cover.](image)
15. Fit screws and washers through the holes in the tap-changer cover and in to the top flange (Fig. 36.) Tighten the screws with the torque prescribed in Section 3.4.

Fig. 36. Screws and washers on the transformer cover.

3.12 Mounting the motor-drive mechanism
Mounting of the motor-drive mechanism is described in a separate instruction manual.

⚠️ WARNING

The motor-drive mechanism must not be installed in an explosive atmosphere. The electrical equipment creates sparks which could cause an explosion.

Do not energize the transformer before the tap-changer and motor-drive mechanism are correctly mounted.

3.13 Mounting accessories
The accessories on the tap-changer cover can be arranged to suit the individual transformer. The installation of accessories is described in the assortment guide.
3.14 Mounting of external drive shafts

The external drive shafts consist of square tubes. They must be connected to the spherical shaft ends of the bevel gear and the motor-drive mechanism by means of two coupling halves.

The bevel gear can be turned so that the horizontal shaft for the motor-drive mechanism is in the right direction. Fig. 36. The limit for turning depends on the arrangement of the accessories, but the shaft can be at any angle.

CAUTION

Before mounting shafts and couplings, all parts must be cleaned and greased to ensure correct function.

3.14.1 Mounting the horizontal drive shaft

1. Make sure that inclination of the shaft is less than 4°. (4° = 70 mm for every 1000 mm of shaft length.)
2. Measure the K1 distance between the spherical shaft ends. See Fig. 38.

Fig. 38. Dimension K1 between the spherical shaft ends.

3. Cut the shaft to the K1 dimension minus 6 mm.
4. Remove burrs and any foreign particles from the shaft.
5. Cut the protective tubes at the non-slotted end so that both have the same length LB1 according to Table 1.

Table 1. Length dimension LB1.

<table>
<thead>
<tr>
<th>K1 (mm)</th>
<th>190 to 290</th>
<th>291 to 600</th>
<th>greater than 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB1 (mm)</td>
<td>((K1+160) / 2)</td>
<td>((K1+210) / 2)</td>
<td>((K1+410) / 2)</td>
</tr>
</tbody>
</table>

Example: If K1 is measured at 390 mm, then LB1 is \((390+210) / 2 = 600 / 2 = 300\) mm

Protective tubes with slotted ends must be used.

Make sure that the slots on the protective tubes are facing downwards.

If K1 is greater than 600 mm, the mounted tubes must overlap each other by at least 300 mm.

Removal and inspection of the couplings must be possible when one of the tubes is pushed into the other.
6. Fit two coupling halves on one end of the shaft. See Fig. 39.

7. Fit six screws and washers in the holes on the coupling halves. See Fig. 40.

8. Push the shaft to the bottom of the fitting in the coupling halves.

9. Tighten the two outer screws. Tightening torque 10 Nm ±10 %. See Fig. 41.

10. Tighten the remaining screws crosswise with the same tightening torque. See Fig. 42.

11. Position the two protective tubes with the slotted ends outwards. See Fig. 43.

12. Fit two hose clips. See Fig. 44.
13. Apply a thin layer of grease to all spherical shaft ends and unpainted surfaces of the bevel gears. Use any of the greases specified in Section 3.2.
14. Connect the shaft with the mounted coupling halves to the bevel gear shaft.
15. Fit two coupling halves on the other end of the shaft: see Fig. 39. Be sure to offset these coupling halves 90° in relation to the couplings mounted in Step 6. See Fig. 45.

![Fig. 45. The couplings should be offset 90° in relation to each other.](image)

16. Fit six screws and washers in the holes on the coupling halves (see Fig. 40) and lightly tighten them.
17. Check that the axial play is no more than 2 mm. See Fig. 46. If necessary, adjust the axial play by moving the couplings on the shaft end.

![Fig. 46. Check that the shaft cannot be moved more than 2 mm in the axial direction.](image)

18. Tighten the outer two screws, see Fig. 41. Tightening torque 10 Nm ±10%.
19. Tighten the remaining screws crosswise (see Fig. 42) with the same tightening torque.
20. Push the two protective tubes horizontally until they touch the bevel gears. See Fig. 47.

![Fig. 47. Push the two protective tubes horizontally.](image)

![Make sure that the slot on the protective tubes is facing downwards.](image)

21. Clamp the protective tubes with the hose clips. See Fig. 48.

![Fig. 48. Clamp two hose clips.](image)

22. Apply the self-adhesive information plates around the tubes at about the middle of the tube length. See Fig. 49.

![Fig. 49. Self-adhesive information plates on the tubes.](image)
3.14.2 Mounting the vertical drive shaft

1. Make sure that inclination of the shaft is less than 4°. (4° = 70 mm for every 1000 mm of shaft length.)
2. Measure the K2 distance between the spherical shaft ends. See Fig. 50.

3. Cut the shaft to the K2 dimension minus 6 mm.
4. Remove burrs and any foreign particles from the shaft.
5. Cut the protective tubes at the non-slotted end so that both have the same length LB2 according to Table 2.

<table>
<thead>
<tr>
<th>K2 (mm)</th>
<th>200 to 290</th>
<th>291 to 600</th>
<th>greater than 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB2 (mm)</td>
<td>(K2+180) / 2</td>
<td>(K2+220) / 2</td>
<td>(K2+410) / 2</td>
</tr>
</tbody>
</table>

6. Fit two coupling halves at one end of the shaft. See Fig. 51.

7. Push the shaft to the bottom of the fitting in the coupling halves.
8. Fit six screws and washers in the holes on the coupling halves. See Fig. 52.

9. Fit screws and washers to the coupling halves.

9. Tighten the two outer screws. Tightening torque 10 Nm ±10 %. See Fig. 53.
10. Tighten the rest of the screws crosswise with the same tightening torque. See Fig. 54.

![Fig. 54. Tighten the remaining screws.](image1)

11. Connect the shaft with the mounted coupling halves to the shaft of the bevel gear. See Fig. 55.

![Fig. 55. Connect the square shaft to the bevel gear.](image2)

12. Place the two protective tubes onto the vertical drive shaft. See Fig. 56.

![Fig. 56. Place protective tubes on the vertical drive shaft.](image3)

13. Fit two hose clips. See Fig. 57.

![Fig. 57. Fit two hose clips.](image4)

14. For BUL motor-drive mechanism, loosen the two screws on the multi-hole coupling at the top of the motor-drive mechanism. See Fig. 58.

![Fig. 58. BUL multi-hole coupling.](image5)

15. For BUE motor-drive mechanism, loosen the two screws on the multi-hole coupling inside the motor-drive mechanism. See Fig. 59.

![Fig. 59. BUE multi-hole coupling.](image6)
16. Apply a thin layer of grease to all spherical shaft ends and unpainted surfaces of the bevel gears. Use any of the greases specified in Section 3.2.

17. Fit two coupling halves at the bottom end of the shaft; see Fig. 51. Be sure to offset these coupling halves 90° in relation to the couplings mounted in Step 6 as shown in Fig. 60.

![Fig. 60. Coupling halves offset by 90°.](image)

18. Connect the bottom end of the square shaft with the mounted coupling halves to the shaft of the motor-drive mechanism. See Fig. 61.

![Fig. 61. Connect the square shaft to the motor-drive mechanism.](image)

19. Fit six screws and washers in the holes on the coupling halves (see Fig. 52) and tighten them lightly.

20. Check that the shaft cannot be moved more than 2 mm in the axial direction (axial play). See Fig. 62. If necessary, adjust the axial play by moving the couplings on the shaft end.

21. Tighten the two outer screws; see Fig. 53. Tightening torque 10 Nm ±10 %.

22. Tighten the remaining screws crosswise (see Fig. 54) with the same tightening torque.

23. Place the protective tube with the greater diameter upwards, facing the bevel gear. See Fig. 63.

![Fig. 62. Check that the shaft cannot be moved more than 2 mm in the axial direction.](image)

![Fig. 63. Place the protective tube with the greater diameter upwards.](image)

24. Secure the tube with a hose clip. See Fig. 64.

![Fig. 64. Fit a hose clip.](image)
25. Check that the motor-drive mechanism is at the exact position. See the appropriate guide for the motor-drive.

The exact position for the BUL is when the roller on the brake arm is in the notch of the cam disc. See Fig. 65.

The exact position for the BUE is when the red indicator flag is in position and the red mark on the brake disc is aligned with the red mark on the brake pad. See Fig. 66.

26. If the motor-drive mechanism is out of position, manually crank the motor-drive mechanism to the exact position according to the info box above.

27. Check that the position indicators on the motor-drive mechanism (Fig. 67) and the tap-changer (Fig. 68) show the same position.

⚠️ **WARNING**

If the position indicators on the motor-drive mechanism and on the tap-changer do not show the same position, a serious transformer failure could occur.

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Fig. 65. BUL: The cam disc and the roller on the brake arm.

Fig. 66. BUE: The red mark on the brake disc.

To access the position indicator, remove the cover. See Fig. 68.

Fig. 67. Position indicator on the motor-drive mechanism.

Fig. 68. Position indicator on the tap-changer.
3.14.3 Synchronization between tap-changer and motor-drive mechanism

1. Loosen the multi-hole coupling. Turn the shaft first to the end-position on one side, and then to the end-position on the other side. Finally, turn halfway back. See Fig. 69.

![Fig. 69. Turning the shaft between end-positions.](image)

2. Check which two holes of the upper multi-hole coupling flange coincide with two holes of the lower multi-hole coupling flange of the motor-drive mechanism. See Figs. 58 (BUL) and 59 (BUE).

3. Fit two screws and locking nuts in the two multi-hole coupling holes that best coincide. Tighten the screws. Tightening torque 10 Nm ±10 %.

4. Pull down the protective tube. See Fig. 70.

5. Make sure that the clearance at the bottom of the tube is between 3 and 5 mm. See Fig. 71.

![Fig. 71. Clearance at the bottom of the tube.](image)

To allow draining from the protective tubes, the amount of clearance at the bottom of the tube is important:

6. Secure the tube with the hose clip. See Fig. 72.

![Fig. 72. Secure the hose clip.](image)

![Fig. 70. Pull down the protective tube.](image)
3.15 Connection to an oil conservator
The tap-changer must be connected to an oil conservator. ABB recommends the use of a separate conservator for the tap-changer with both the oil and air side separated from the main conservator of the transformer.

The volume of the conservator should be such that there is oil left in the conservator even at the lowest expected oil temperature and that no overflow can occur at the highest expected oil temperature.

A suitable dimension of the tube for connection to the conservator is an inner diameter of approximately 20 mm. See Fig. 73. The tube should be inclined at least 3 degrees to avoid gas cushions in the tube. A valve in the connection to the conservator is recommended.

The conservator must be equipped with a breathing device that does not allow moist air into the conservator and that allows the gas from arcs to dissipate.

The conservator should also be equipped with an oil level indicator, and an alarm contact for low oil level is recommended.

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If oil filling is performed under a vacuum without an oil conservator, this section is carried out after oil filling.

1. Remove the nuts from the transport cover on the pipe connection flange. See Fig. 74.

2. Remove the transport cover on the pipe connection flange. See Fig. 75. Make sure that the O-ring is in place and that it is not damaged. See Fig. 76.
3. Connect the oil conservator pipe to the tap-changer's pipe connection flange. See the dimension drawing for the specified model, and choose one of the flanges A-C.

![Fig. 77. Connection of the oil conservator pipe.](image)

4. Fit the nuts on the studs. Tighten the nuts with a tightening torque of 49 Nm ±10%. See Fig. 78.

![Fig. 78. Nuts on the oil conservator pipe.](image)
3.16 Before operation

1. Check that the position indicator on the motor-drive mechanism shows the same position as the indicator inside the top-cover of the tap-changer. See Figs. 67 and 68.

**WARNING**

If the position indicators on the motor-drive mechanism and on the tap-changer do not show the same position, a serious transformer failure could occur.

To access the position indicator, remove the cover.

2. Remove the locking device on the motor-drive mechanism. See Fig. 79.

3.17 Installation of an oil tap

To simplify taking oil samples, be sure to install an oil tap as shown in Fig. 80.

The pipe must have an inner diameter of Ø10 mm.

**WARNING**

Make sure that the oil tap is arranged so that oil sampling can be performed from ground level while the transformer is energized.
3.18 Installation of safety device
Installation and commissioning of the safety device is described in the assortment guide.

3.19 Oil filling
3.19.1 Oil quality
The tap-changer contains about 300 liters of oil. The oil quality should be LC set -30° according to IEC 60296:2012.

The oil should also comply with IEC 60422:2005.

3.19.2 Filling methods and restrictions
Oil filling can be carried out using any of the following methods:
- At atmospheric pressure
- Under vacuum

The tap-changer housing is designed to withstand a vacuum on one side and atmospheric pressure on the other.

⚠️ CAUTION

The pressure difference between the inside and outside of the housing may not exceed 100 kPa.

⚠️ CAUTION

Be aware of slipping risks caused by oil spillage.

ℹ️ The oil dissolves gases, especially if degassed oil is used.

3.19.3 Correct oil level
If possible, the oil levels of the oil conservators on the transformer tank and the tap-changer should be the same. The oil level of the oil conservator on the tap-changer may never be higher than the oil level of the transformer oil conservator.

At +20 °C, oil is filled to the level where the pointer on the oil level indicator points half-way between MIN and MAX.

For temperatures other than +20 °C, proceed as follows:
- For every 10 °C increase of temperature, adjust the oil level upwards a tenth of the scale range on the oil level indicator.
- For every 10 °C decrease of temperature, adjust the oil level downwards a tenth of the scale range on the oil level indicator.

3.19.4 Filling at atmospheric pressure
It is not necessary to perform Steps 1 and 2 below. These two steps are only described to speed oil filling. Oil filling can be satisfactorily performed by merely following Steps 3 through 10:

1. Remove the inspection cover.
2. Pump in oil until it reaches the mechanism.
3. Open the conservator valve, if any.
4. Remove the breathing device for the conservator for the tap-changer.
5. Connect the pump to the oil valve on the tap-changer cover.
6. Open the valve.
7. Pump in oil to the correct level. The oil level is shown on the oil level indicator. (For correct oil level, see Section 3.22.3.)
8. Close the oil valve.
9. Disconnect the pump.
10. Refit the pipe or the breather. Make sure that the connections are airtight – use sealing tape on the threads and O-rings in the flanges.

⚠️ CAUTION

Do not energize the transformer earlier than three hours after oil filling at atmospheric pressure. This waiting period is needed to allow air bubbles to disappear.
3.19.5 Filling under vacuum
Oil filling under vacuum can be carried out with the conservator. After filling under vacuum, no standing time is needed. The methods below ensure that no stipulated pressure differences are exceeded.

**CAUTION**
To fill under vacuum, a vacuum-proof conservator must be used.

1. Make a connection between the oil conservator for the transformer and the oil conservator for the tap-changer. See Fig. 81.
2. Open the valve between the tap-changer and the conservator.
3. Close the oil valve.
4. Put the transformer under vacuum. (The tap-changer is then put under vacuum automatically.)
5. Let oil in through the oil valve of the tap-changer. For connection dimensions, see Fig. 73.
6. When the oil level indicator has reached the correct level, close the oil inlet. For correct oil level, see Section 3.19.3.
7. When atmospheric pressure is restored in the transformer, remove the connection between the transformer and the tap-changer.
8. Connect the breathing device to the oil conservator for the tap-changer. Make sure the connection to the breathing device is properly sealed.

3.20 Electrical connection
Before the transformer is energized, tests must be performed to make sure that all mechanical and electrical connections are correct. The tests are also performed to check the proper function of the tap-changer and the motor-drive mechanism.

**WARNING**
Do not energize the transformer until oil has been filled.

1. Connect the ground connection from the transformer to the ground terminal on the tap-changer flange. See Fig. 82.
2. Connect the ground connection from the transformer to the ground terminal on the motor-drive mechanism.
3. Connect the motor supply and the control supply to the correct terminals on the motor-drive mechanism. See the circuit diagram supplied with the tap-changer.
3.21 Testing
When testing the transformer, the tap-changer can be operated either by the hand crank or electrically. When operating electrically, the motor-drive mechanism must be connected.

1. Make sure that the motor-drive mechanism and the tap-changer show exactly the same position. See Fig. 67 and Fig. 68.

**WARNING**
If the position indicators on the motor-drive mechanism and on the tap-changer do not show the same position, a serious transformer failure could occur.

To access the position indicator, remove the cover. See Fig. 68.

2. Operate the tap-changer with the hand crank, counting the number of turns from the exact position until the tap-changer operates.
   - For BUL – the tap-changer should operate after 11.5 ± 1 turn of the hand crank.
   - For BUE – the tap-changer should operate after 19 ± 1.5 turns of the hand crank.
If not, one of the shaft couplings of the gears is incorrectly mounted.

3. Manually crank the motor-drive mechanism to a position in the middle of the range. See Fig. 67.
4. Turn the control selector switch to the local position.
5. Send an impulse for a raise operation.

If the phase sequence is incorrect (three-phase supply), the motor-drive mechanism starts in the lower direction. The motor-drive mechanism moves back and forth around its service position until the control selector switch is turned to 0.

6. If the phase sequence is incorrect, reverse two of the motor supply cables to get the correct sequence.

**WARNING**
Dangerous voltage!

For a BUL motor-drive mechanism, continue to Step 7.

For a BUE motor-drive mechanism, continue to Step 10.

For BUL:
7. Run the motor-drive mechanism.
8. Check that the center of the notch in the cam disc stops within ±2 mm of the center of the roller on the brake arm. See Fig. 65.
   If it does not stop within the tolerances, see the maintenance guide for the motor-drive mechanism.

For BUE:
10. Run the motor-drive mechanism.
11. Check that the red mark on the brake disc stops within the tolerance limits. See Fig. 66.
12. If the brake disc is outside the tolerance limits, increase or decrease pressure on the springs; see the maintenance guide for the motor-drive mechanism.

For BUE and BUL
14. Check that the position indicator on the motor-drive mechanism shows the same position as the indicator inside the cover of the tap-changer. See Figs. 67 and 68.

**WARNING**
If the position indicators on the motor-drive mechanism and on the tap-changer do not show the same position, a serious transformer failure could occur.

To access the position indicator, remove the cover. See Fig. 68.

15. Operate one step.
16. Check that the tap-changer follows the motor-drive mechanism.
17. Operate the driving mechanism electrically between the end-positions.
18. Check the end-stops. When attempting to operate it electrically beyond the end-position, the motor should not start.
19. Check the mechanical end-stop by attempting to manually crank it beyond the end-position. After a couple of turns on the hand crank, it should be mechanically stopped.
20. Manually crank back to the end-position.
21. Operate the tap-changer electrically to the other end-position.
22. Repeat the test procedure above.
WARNING

The transformer may never be energized with an inoperable end-stop.

The tap-changer installation is now complete. Proceed with testing the transformer.
4. Transport

4.1 General
If the transport dimensions allow, the transformer may be transported without dismantling any parts of the tap-changer.

If the motor-drive mechanism or any parts of the shaft system must be dismantled for transport, the parts must be marked to ensure they can be properly mounted on site and with a minimum of work.

If any of the accessories on the tap-changer must be dismantled, the openings on the tap-changer must be protected with transport covers.

If the transformer is transported without oil, the tap-changer must also be drained.

4.1.1 Transport with mounted conservator
If the oil conservator is connected to the tap-changer during transport, the tap-changer must be filled with oil to the normal operating level.

4.1.2 Transport with dismounted conservator
If the conservator is to be removed during transport, the oil level in the tap-changer must be lowered.

1. Fit an oil hose to the center hole of the tap-changer cover. See Fig. 83.

Fig. 83. Fit an oil hose to the center hole.

2. Drain oil until the oil level is 150 mm below the top cover.

4.1.3 Protection of motor-drive
The motor-drive mechanism must be protected against condensation. Therefore, energize the heater when power is available. If this cannot be done, place a drying agent inside the motor drive cabinet and seal the vents.