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1. Safety

1.1 General
This user’s guide must be read and understood must 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 against unsafe practices.

CAUTION may also indicate property-damage-only hazards.

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 somewhat harmful. Fumes from unused warm oil may irritate the respiratory organs and the eyes. After long and repeated contact with transformer oil, the skin becomes very dry. Avoid contact with the oil as much as possible and use oil-tight protective gloves when handling the oil.

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

1.3.2 Environmental safety
Collect used oil in oil drums.

An absorbing agent should be used when cleaning up waste oil. Treat waste oil as hazardous to the environment.

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, extinguish with a powder, foam or carbon acid extinguishing agent.
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.

**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 for such work.

**CAUTION**

After a pressure relay trip, contact 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 tapping connection of a winding while the transformer is under load. The main purpose is to maintain a constant voltage out 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 numerous different circuit solutions are available, the selected solution has been found to offer the best combination of technical performance and potential for economic operation. 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.

The electrical circuit principle for the VUBB is shown in Figs. 1-18. The purpose of the operation is to commute the load from one tap to the other in order to change the voltage.

Depending on in which direction the center shaft is rotating, two different contact sequences are obtained – either the main contacts operate first, or in the other direction, the transition contacts operate first.

The figures on the following pages show the contact sequence along with the physical position of the interrupter.
2.2.1 Switching sequence, operation with resistor side first

1. Position for continuous load through fixed contact 1.

2. Resistor auxiliary contact disconnects from fixed contact 1.

3. Resistor vacuum interrupter opens.

4. Resistor auxiliary contact connects to fixed contact 2.

5. Resistor vacuum interrupter closes, producing a circulating current.
6. Main vacuum interrupter opens, breaking the circulating current and commuting the load current to the resistor branch.

7. Main auxiliary contact disconnects from fixed contact 1.

8. Main auxiliary contact connects to fixed contact 2.

9. Main vacuum interrupter closes, commuting the load current to the main branch. Continuous load on fixed contact 2.
2.2.2 Switching sequence, operation with main contact first

1. Position for continuous load through fixed contact 2.

2. Main vacuum interrupter opens, breaking the load current, and in doing so commutes it to the resistor branch.

3. Main auxiliary contact disconnects from fixed contact 2.

4. Main auxiliary contact connects to fixed contact 1.

5. Main vacuum interrupter closes. The load current commutes to the main branch, producing a circulating current.
6. Resistor vacuum interrupter opens, breaking the circulating current.

7. Resistor auxiliary contact disconnects from fixed contact 2.

8. Resistor vacuum interrupter closes.

9. Resistor auxiliary contact connects to fixed contact 1.
2.3 System overview
The implementation of vacuum technology improves breaking capacity, increases contact life and reduces maintenance.

The design allows easy access to the function control for the switching sequence.

The VUBB tap-changer is of the in-tank design. The motor-drive mechanism is attached to the transformer tank and connected to the tap-changer by means of drive shafts and a bevel gear. The motor-drive mechanism is not described in this manual.

The tap-changer is mainly comprised of a housing, a mechanical drive system, a change-over selector and a selector switch.

The tap-changer is designed so that it is suitable for both cover mounting and yoke-mounting (pre-mounting on the transformer’s active part).

Cover-mounting means that the tap-changer is lowered through a hole in the transformer cover and then bolted straight onto the transformer cover. See Fig. 19.

Yoke-mounting means that the tap-changer is temporarily placed on a fork located on the active part of the transformer. See Fig. 20. The transformer cover is then lowered onto the tank, and the tap-changer is lifted and bolted to the cover. Yoke-mounting allows the transformer manufacturer to connect the windings to the tap-changer before drying and without having the transformer cover mounted.

The tap-changer type VUBB can be switched using:

- Linear switching, see Fig. 21.
- Plus/minus switching, see Fig. 22.
- Coarse/fine switching, see Fig. 23.

The general arrangement of a tap-changer system can be executed using:

- Three-phase, star point connection, see Fig. 24.
- Three-phase delta, fully insulated connection, see Fig. 25.
2.3.1 Types of switching

Linear switching (type L)
With linear switching, the regulating range is equal to the voltage of the tapped winding. No change-over selector is used.

Plus/minus switching (type R)
With plus/minus switching, the change-over selector extends the regulating range to twice the voltage of the tapped winding by connecting the main winding to different ends of the regulating winding.

Coarse/fine switching (type D)
With coarse/fine switching, the change-over selector extends the regulating range to twice the voltage of the tapped winding by connecting or disconnecting the coarse regulating winding.
2.3.2 Types of connection

Three-phase, star point (N)
Only one unit is required for all three phases. The transformer’s neutral point is in the tap-changer.

Fig. 24. Three-phase, star point connection.

Three-phase delta, fully insulated (T)
Only one unit is required for all three phases.

Fig. 25. Three-phase delta, fully insulated connection.
2.3.3 Housing
The purpose of the housing is to seal and provide mechanical support.

The top section forms the flange that is used for mounting to the transformer cover, and for bearing the gear box for the operating shafts. The top section includes a connection for the conservator pipe and draining connections, a grounding terminal, the supervisory device and the cover with its gasket.

The housing has high quality seals that guarantee vacuum and overpressure-proof performance under all service conditions. During operation, some particles from mechanical wear will be produced. These pollutants must not enter the transformer, and the housing is therefore designed to provide hermetical sealing between the vacuum selector switch and the transformer.

The top and bottom sections of the housing cylinder are made of cast aluminum. They are attached to a cylinder of fiberglass-reinforced plastic. The bushings through the cylinder wall are sealed by O-ring gaskets. Each unit is tested under vacuum, and the outside is exposed to helium and checked for leaks with a helium gas detector.

2.3.4 Selector switch
The selector switch is used to execute the electrical sequence described in Sections 2.2.1 and 2.2.2.

The VUBB tap-changer contains three selector switches, one per phase.

The function of the selector switch is to select a tap in the tap winding and to carry and commutate the load current. The selector has multiple fixed contacts, each connected to a different tap in the regulating winding.

2.3.5 Change-over selector
The tap-changer can also be equipped with a change-over selector for plus/minus or coarse/fine switching; see Figs. 22 and 23.

The selector switch has a maximum of 10 positions, but with the change-over selector, this number can be doubled.

2.4 Contacts
The contacts inside the selector switch are used for carrying the electrical load. The contacts are comprised of fixed and operating contacts. The fixed contacts are located on the housing. The operating contacts are located on the selector switch shaft.

2.5 Vacuum interrupters
During switching operations of vacuum tap-changers, arcing takes place in the vacuum interrupters and not in oil.

2.6 Transition resistors
The purpose of the transition resistors is to allow a make-before-break operation by limiting the circulating current when bridging two taps.

2.7 Spring-loaded mechanism
The spring-loaded mechanism ensures a fast and complete switching sequence even if the power supply fails.

The mechanism is normally operated by the motor-drive unit, but can also be hand-cranked by an operator.

The motor-drive mechanism and bevel gear are mounted on the transformer tank, and the drive shafts are mounted to complete the assembly of the motor-drive mechanism, bevel gear and tap-changer before oil filling and testing.

2.8 Motor-drive mechanism
The bevel gear, mounted on the cover, transfers the motion of the motor-drive mechanism, via the drive shafts, to the tap-changer's spring-loaded mechanism.

The motor-drive mechanism provides the force for operating the tap-changer. Energy is provided from a motor through a series of gears and out through a drive shaft. Several features are incorporated within the mechanism to lengthen service intervals and improve reliability.

2.9 Accessories and protection devices
The tap-changer can be equipped with various protection devices. The standard protection device is the pressure relay. An oil flow relay is also available.

A pressure relief device with an alarm signal is also available, as well as certain other supervisory sensors.

For more information about accessories and protection devices, see the technical description. 1ZSC000562-AAD.
Fig. 26. VUBB overview.
2.10 Rating plate
The rating plate is on the door of the motor-dive unit.

The unit’s serial number is on the top flange of the tap-changer.
3. Commissioning

3.1 General
This section describes tasks to be carried out when the transformer is being installed and tested on site.

⚠️ CAUTION ⚠️
The motor-drive mechanism must be protected against condensation.

Make sure that the heater is energized when power is available. When power is not available, put drying agent inside the motor-drive cabinet and seal the vents.

3.2 Reassembly
The conservator and accessories that may have been removed during transport must be remounted.

The installation of accessories is described in the assortment guide.

Depending on the transport requirements, the transformer may or may not be delivered with the motor-drive mechanism and drive shaft system attached.

⚠️ WARNING ⚠️
Before any work is carried out on the tap-changer, make sure that the transformer is disconnected and that grounding is properly executed. Obtain a signed certificate from the engineer in charge.

⚠️ 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.

Remember to place O-rings on the flanges.

1. Mount the motor-drive mechanism if it is not mounted upon delivery. Mounting of the motor-drive mechanism is described in a separate instruction manual.
2. Mount the external drive shafts if they are not mounted upon delivery. See Section 3.6.

⚠️ WARNING ⚠️
The motor-drive mechanism must not be installed in an explosive atmosphere. The electrical equipment creates sparks that can cause an explosion.

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

3. Refit the conservator.
4. Refit the accessories.

The pressure relay is usually delivered in a separate package and installed upon commissioning.

The tap-changer may be delivered filled with oil or without oil.

3.3 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 screwdrivers
– Allen keys for 5- and 6-mm sockets
– Hand crank LL 117 016-M
– Dynamometric wrenches, 5-85 Nm
– Tool for opening the oil drum
– Bucket, 10 liters
– 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
3.4 Tightening torques
The following tightening torques are recommended unless otherwise stated in this user’s guide:

- M6  10 Nm ±10 %
- M8  24.5 Nm ±10 %
- M10 49 Nm ±10 %
- M12 84 Nm ±10 %

3.5 Oil filling
3.5.1 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.

3.5.2 Filling methods and restrictions
Oil filling can be carried out using one of the following methods:

- At atmospheric pressure
- Under vacuum

The tap-changer housing is designed to for 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 the risk of slipping due to spilled oil.

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

3.5.3 Correct oil level
If possible, the oil levels of the oil conservators for the transformer tank and tap-changer should be the same. The oil level of the oil conservator for 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 of the oil level indicator.
- For every 10 °C decrease of temperature, adjust the oil level downwards a tenth of the scale range of the oil level indicator.

3.5.4 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 only 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 tap-changer conservator.
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 3.5.3.)
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 on the flanges.

⚠️ CAUTION ⚠️

Wait at least three hours before energizing the transformer after filling oil at atmospheric pressure. This waiting period is necessary to allow air bubbles to dissipate.
3.5.5 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. Fig. 29.

![Fig. 29. Vacuum filling overview.](image)

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 as well.)
5. Let oil in through the oil valve on the tap-changer. For connection dimensions, see Fig. 30.

![Fig. 30. Connection dimensions.](image)

6. When the oil level indicator has reached the correct level, close the oil inlet. For correct oil level, see Section 3.5.3.
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.
3.6 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 correctly positioned. See Fig. 31. The limit for turning depends on the arrangement of the accessories, but the shaft can be at any angle.

![Fig. 31. The bevel gear can be turned 360°.](image)

**CAUTION**

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

Let the parts of the shaft system that should be dismantled before transporting the transformer to the site keep their identification numbers according to the packing list to simplify the remounting of the shaft system on site.

The tubes around shafts and couplings are for protection.

3.6.1 Mounting of horizontal drive shaft

1. Make sure that inclination of the shaft is less than 4°. 
   \(4^\circ = 70 \text{ mm for every } 1000 \text{ mm of shaft length.}\)

   ![Protective tubes with slotted ends must be used.](image)
   
   Make sure that the slots on the protective tubes are facing downwards.

   Removal and inspection of the couplings must be possible when one of the tubes is pushed into the other.

2. Fit two coupling halves on one end of the shaft. See Fig. 32.

![Fig. 32. Fit two coupling halves on the square shaft.](image)

3. Fit six screws and washers in the holes on the coupling halves. See Fig. 33.

![Fig. 33. Fit screws and washers to the coupling halves.](image)
4. Push the shaft to the bottom of the fitting in the coupling halves.

5. Tighten the two outer screws. Tightening torque 10 Nm ±10 %. See Fig. 34.

![Fig. 34. Tighten the two outer screws.](image)

6. Tighten the remaining screws crosswise with the same tightening torque. See Fig. 35.

![Fig. 35. Tighten the remaining screws.](image)

7. Position the two protective tubes with the slotted ends outwards. See Fig. 36.

![Fig. 36. Position the tubes with the slotted ends outwards.](image)

8. Fit two hose clips. See Fig. 37.

![Fig. 37. Fit two hose clips.](image)

9. 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 3.3.

10. Connect the shaft with the mounted coupling halves to the bevel gear shaft.

11. Fit two coupling halves on the other end of the shaft; see Fig. 32. Be sure to offset these coupling halves 90° in relation to the couplings mounted in step 2. See Fig. 38.

![Fig. 38. The couplings should be offset 90° in relation to each other.](image)
12. Fit six screws and washers in the holes on the coupling halves (see Fig. 33) and lightly tighten them.
13. Check that the axial play is no more than 2 mm. See Fig. 39. If necessary, adjust the axial play by operating the couplings on the shaft end.

14. Tighten the outer two screws; see Fig. 34. Tightening torque 10 Nm ±10 %.
15. Tighten the remaining screws crosswise (see Fig. 35) with the same tightening torque.
16. Push the two protective tubes horizontally until they touch the bevel gears. See Fig. 40.

17. Clamp the protective tubes with the hose clips. See Fig. 41.

18. Apply the self-adhesive information plates around the tubes at about the middle of the tube length. See Fig. 42.

---

Make sure that the slot on the protective tubes is facing downwards.

---

Fig. 39. Check that the shaft cannot be moved more than 2 mm in the axial direction.

Fig. 40. Push the two protective tubes horizontally.

Fig. 41. Clamp two hose clips.

Fig. 42. Self-adhesive information plates on the tubes.
3.6.2 Mounting of vertical drive shaft

1. Make sure that inclination of the shaft is less than 4°.
   \((4° = 70 \text{ mm for every } 1000 \text{ mm of shaft length.})\)
2. Fit two coupling halves at one end of the shaft. See Fig. 43.

![Fig. 43. Fit two coupling halves on the square shaft.](image)

3. Push the shaft to the bottom of the fitting in the coupling halves.
4. Fit six screws and washers in the holes on the coupling halves. See Fig. 44.

![Fig. 44. Fit screws and washers to the coupling halves.](image)

5. Tighten the two outer two screws. Tightening torque 10 Nm ± 10 %. See Fig. 45.

![Fig. 45. Tighten the two outer screws.](image)

6. Tighten the remaining screws crosswise with the same tightening torque. See Fig. 46.

![Fig. 46. Tighten the remaining screws.](image)
7. Connect the shaft with the mounted coupling halves to the shaft of the bevel gear. See Fig. 47.

8. Place the two protective tubes on the vertical drive shaft. See Fig. 48.

9. Fit two hose clips. See Fig. 49.

10. For BUL motor-drive mechanism, loosen the two screws on the multi-hole coupling at the top of the motor-drive mechanism. See Fig. 50.

11. For BUE motor-drive mechanism, loosen the two screws on the multi-hole coupling inside the motor-drive mechanism. See Fig. 51.
12. 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 3.3.

13. Fit two coupling halves at the bottom end of the shaft; see Fig. 43. Be sure to offset these coupling halves 90° in relation to the couplings mounted in step 2 as shown in Fig. 52.

Fig. 52. Coupling halves offset by 90°.

14. Connect the bottom end of the square shaft with the mounted coupling halves to the shaft of the motor-drive mechanism. See Fig. 53.

Fig. 53. Connect the square shaft to the motor-drive mechanism.

15. Fit six screws and washers in the holes on the coupling halves (see Fig. 44) and tighten them lightly.

16. Check that the shaft cannot be moved more than 2 mm in the axial direction (axial play). See Fig. 54. If necessary, adjust the axial play by moving the couplings on the shaft end.

Fig. 54. Check that the shaft cannot be moved more than 2 mm in the axial direction.

17. Tighten the two outer screws; see Fig. 45. Tightening torque 10 Nm ±10 %.

18. Tighten the remaining screws crosswise (see Fig. 46) with the same tightening torque.

19. Place the protective tube with the greater diameter upwards, facing the bevel gear. See Fig. 55.

Fig. 55. Place the protective tube with the greater diameter upwards.

20. Secure the tube with a hose clip. See Fig. 56.

Fig. 56. Fit a hose clip.
21. Check that the motor-drive mechanism is at the EXACT position.

The exact position for the BUL is when the roller on the brake arm is in the notch of the cam disc. See Fig. 57.

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. 58.

22. 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.

23. Check that the position indicators on the motor-drive mechanism (Fig. 59) and the tap-changer (Fig. 60) 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.

---

Fig. 57. BUL2: Cam disc and roller on the brake arm.

Fig. 58. BUE: Red mark on the brake disc.

Fig. 59. Position indicator on the motor-drive mechanism.

Fig. 60. Position indicator on the tap-changer.
3.7 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. 59 and Fig. 60.

**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. 60.

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 it does 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. 59.

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 in order to get the correct sequence.

**WARNING**

Dangerous voltage!

For a BUL2 motor-drive mechanism, continue at step 7.

For a BUE motor-drive mechanism, continue at step 10.

**For BUL2:**

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. 57.
   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. 59.

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. 59 and 60.

**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. 60.

15. Operate one step.

16. Check that the tap-changer follows the motor-drive mechanism.

17. Operate the drive 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 of 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 must never be energized with an inoperable end-stop.

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

### 3.8 Energizing

The tap-changer can now be energized and commissioned.

**WARNING**

Before any work is carried out on the tap-changer, make sure that the transformer is disconnected and that grounding is properly executed. Obtain a signed certificate from the engineer in charge.

### 3.9 Putting into operation

Put the motor-drive mechanism into operation by following the instructions given in the BUE and BUL installation and commissioning guide.

- Check the oil level one month after filling. It is usual for the oil level of the oil conservator to decrease due to gas absorption in the oil.
WARNING

Small amounts of explosive gases are constantly discharged from the breathing devices (dehydration 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.

CAUTION

The hand crank must not be inserted during electrical operation.

The pressure relay is a calibrated monitoring instrument. It must be handled with care and protected against careless handling or any kind of mechanical damage.

If a power supply failure occurs during operation, the interrupted operation will be completed once the power returns.

If the tap-changer is not at its exact position and the hand crank is pulled out, the motor-drive mechanism will start and go to the exact position if the power supply is on.

4. Operation

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. 62.

Fig. 62. Pull down the protective tube.

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

5. Make sure that the clearance at the bottom of the tube is between 3 and 5 mm. See Fig. 63.

Fig. 63. Clearance at the bottom of the tube.

6. Secure the tube with the hose clip. See Fig. 64.

Fig. 64. Secure the hose clip.

4.1 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. 61.

Fig. 61. Turning the shaft between end-positions.
The VUBB tap-changer has been designed to provide maximum reliability. The simple and robust design provides a service life equal to the service life of the transformer. A minimum of maintenance is required for trouble-free operation.

5.1 General
Maintenance of the tap-changer is organized into three major steps:

**Inspection** – Carried out by site personnel.

**Maintenance** – Carried out by ABB personnel.

**Replacement of the complete switching mechanism including vacuum interrupters** – Carried out by the manufacturer.

Furthermore, the quality of the oil must be checked according to IEC 60422:2005. This is carried out by site personnel.

**WARNING**

Before any work is carried out on the tap-changer, make sure that the transformer is disconnected and that grounding is properly executed. Obtain a signed certificate from the engineer in charge.

Before starting any work inside the motor-drive mechanism, the auxiliary power must be switched off. Note that the motor, contactors and heating element may be energized from separate sources.

**CAUTION**

Before carrying out work on the tap-changer, put the LOCAL/REMOTE switch on the motor-drive mechanism to position "0". Shutting the door of the motor-drive mechanism and locking it with a padlock is also recommended when work is carried out on the tap-changer. The key should be kept by the technician. This is done to avoid unexpected starting of the motor-drive mechanism.

Be aware of the risk of slipping due to spilled oil.

5.2 Inspection

It is recommended that the tap-changer be inspected at the same time as other work is carried out on the transformer. The inspection should be carried out yearly, and can be done while the transformer is in service. This inspection is carried out by site personnel.

The inspection consists of a visual check of the motor-drive mechanism and the conservator. The quality of the insulating oil is also checked. During this inspection, the counter is read to determine when maintenance is due.

### Table 1. Maintenance schedule.

<table>
<thead>
<tr>
<th>Time or number of operations</th>
<th>Inspection</th>
<th>Oil sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearly</td>
<td></td>
<td>After 6, 11, 15 years, and then every 3rd year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of action</th>
<th>Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check oil level at conservator</td>
<td>x</td>
</tr>
<tr>
<td>Check the breather</td>
<td>x</td>
</tr>
<tr>
<td>Visual check of motor-drive mechanism</td>
<td>x</td>
</tr>
<tr>
<td>Check the motor</td>
<td>x</td>
</tr>
<tr>
<td>Check the counter</td>
<td>x</td>
</tr>
<tr>
<td>Check the heater</td>
<td>x</td>
</tr>
<tr>
<td>Test of oil quality (IEC 60422)</td>
<td>x</td>
</tr>
<tr>
<td>Dissolved gas analysis (DGA)</td>
<td>x</td>
</tr>
</tbody>
</table>

(See IEC 60599 for further information.)

**WARNING**

The inspection must be carried out from ground level since the transformer is energized.

**CAUTION**

Permission must be obtained for inspection as well as for operation of the tap-changer.

1. Check the motor on the motor-drive mechanism.
2. Check the counter on the motor-drive mechanism.
3. Check the heater on the motor-drive mechanism.
4. Register the counter’s value on the motor-drive mechanism.

Follow the instructions given in the separate guide for the motor-drive mechanism.

The registered number of operations should be noted each time inspection and maintenance are conducted.
5. Check the oil level in the conservator. The level must be as stipulated in the instructions from the transformer manufacturer.

**WARNING**

The oil in the tap-changer housing may be hot. Observe caution!

6. Check the breather according to the instructions from the transformer manufacturer. If more than half of the drying agent has changed color, it must be dried or replaced. The drying agent normally starts to change color from the bottom of the breather. If it changes color at the top of the breather, there is a leakage in the connections to the conservator. Locate the leakage and seal it.

**WARNING**

The breathers and the tube from the conservator contain explosive gases. No open fires, hot surfaces or sparks may be present when removing the breather.

5.3 Checking oil quality

Check the quality of the oil according to IEC 60422:2005.

To simplify oil sampling, the transformer should have an oil tap as shown in Fig. 65.

An oil filter unit is normally not required on the VUBB tap-changer. But, if the tap-changer is equipped with an oil filter unit from ABB, it should be inspected once a year.

5.4 Maintenance

For maintenance, please contact ABB or make sure that personnel performing maintenance are trained and certified by ABB.

Maintenance of the tap-changer should be performed regularly at intervals of 300,000 operations; see Table 2. The relevant information is stated on the rating plate. This permits confirmation of mechanical integrity and monitoring of contact wear, and the necessary preparations can be made for replacing the vacuum interrupters.

**Table 2.**

<table>
<thead>
<tr>
<th>No. of operations</th>
<th>Main activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>300,000</td>
<td>Maintenance (sequence measurement via inspection hole on cover)</td>
</tr>
<tr>
<td>600,000</td>
<td>Replacement of switching mechanism (including vacuum interrupters)</td>
</tr>
<tr>
<td>900,000</td>
<td>Maintenance (sequence measurement via inspection hole on cover)</td>
</tr>
<tr>
<td>1,200,000</td>
<td>End of life</td>
</tr>
</tbody>
</table>

5.5 Replacement of the complete switching mechanism including vacuum interrupters

The vacuum interrupters are sensitive and the settings must be exact. It is thus important that replacement is performed by an ABB-certified technician. Contact ABB or make sure that personnel performing replacement of the complete switching mechanism including vacuum interrupters are trained and certified by ABB.

The estimated contact life of the vacuum interrupters in the selector switch at rated load is stated on the rating plate of the tap-changer. Also see Table 2.

Fig. 65 Oil sampling tap.
6. Troubleshooting

This chapter provides information used to locate faults on the tap-changer. Instructions for correcting faults, replacing parts, etc. are in Section 7.

<table>
<thead>
<tr>
<th>Error condition</th>
<th>Troubleshooting procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>High oil level alarm</td>
<td>A rising oil level in the tap-changer conservator may indicate leakage between the tap-changer and the transformer main tank.</td>
</tr>
<tr>
<td></td>
<td>1. Make sure that the alarm is not due to overfilling upon commissioning or maintenance. This can be checked by adjusting the oil level according to Section 3.5.3.</td>
</tr>
<tr>
<td></td>
<td>2. Recheck the oil level later.</td>
</tr>
<tr>
<td>Low oil level alarm</td>
<td>A low oil level in the tap-changer may indicate leakage.</td>
</tr>
<tr>
<td></td>
<td>1. If there is no visible leakage, adjust the oil level according to Section 3.5.3.</td>
</tr>
<tr>
<td></td>
<td>2. Check the oil level later.</td>
</tr>
<tr>
<td>Pressure relay has tripped</td>
<td>For troubleshooting instructions regarding the pressure relay, see the assortment guide.</td>
</tr>
<tr>
<td></td>
<td>Note the number of operations and then lift the tap-changer insert. Inspect the tap-changer according to the maintenance guide.</td>
</tr>
<tr>
<td>The control system or the motor-drive mechanism is malfunctioning</td>
<td>Follow the instructions given in the separate guide for the motor-drive mechanism.</td>
</tr>
<tr>
<td>Drying agent has changed color from the bottom of the breather</td>
<td>Dry or replace the drying agent.</td>
</tr>
<tr>
<td>Drying agent has changed color from the top of the breather</td>
<td>There is a leakage in the connections to the conservator. Locate the leakage and seal it.</td>
</tr>
</tbody>
</table>

**CAUTION**

Do perform service on the transformer after a pressure relay trip; contact the manufacturer.
7. Repairs and adjustments

7.1 General
Repairs on the VUBB tap-changer fall into two categories:

Repairs – Replacing worn or end-of-service-life parts

Modifications – Improving the already very high standard of reliability and taking actions to prolong the service life of the equipment. Modifications may only be as issued by ABB.

The modifications fall into two areas:

Immediate – The modification is to be made at the earliest possible opportunity.

Routine – The modification is to be made during routine service.

**WARNING**
When oil that has been used in a selector switch housing is pumped out, all tubes and hoses that can conduct electricity must be grounded to avoid the risk of explosion due to the gases produced by arcs during service.

8.1.1 Serial number
Before consulting ABB for technical advice, for assistance with repairs, to order consumables or to complete repairs, the tap-changer serial number must be available. The serial number can be found on the rating plate on the motor-drive mechanism and on the flange of the selector switch housing (see Section 2.19).

The serial number must be stated in all correspondence with the manufacturer. Failure to use the serial number may cause delays.

7.2 Oil leakage
7.2.1 General
This instruction is a guide in dealing with oil leakage from the tap-changer. Leakage might be caused by one of the following:

– Damaged O-ring at the top cover of the tap-changer.
– Leakage between the bevel gear flange and the transformer cover.

7.2.2 Tools required
Standard set of metric combination wrenches.

7.2.3 Materials and spare parts required
– O-rings
– Grease for ball bearings (Section 3.3).

7.2.4 Procedure

**WARNING**
Before any work is carried out on the tap-changer, make sure that the transformer is disconnected and that grounding is properly executed. Obtain a signed certificate from the engineer in charge.

**CAUTION**

Be aware of the risks of slipping due to oil leakage.

Protect the tap-changer from water.

1. Check if oil is leaking anywhere else than from the tap-changer.

The following procedure applies to all connections other than the connection between the bevel gear and the top cover.

2. Retighten the nuts at the top of the cover. Tightening torque 84 ±10 %. See Fig. 66.

![Fig. 66. Bolts on top cover.](image-url)
If oil leakage remains, the O-ring must be replaced:

3. Lower the oil level in the tap-changer by 100-150 mm.
4. Remove the bolts and washers from the top cover. See Fig. 66.

**CAUTION**

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

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

5. Carefully lift the cover at least 10 cm straight up before moving it horizontally. See Fig. 67.

Be sure not to damage the bevel gear and the pipe when lifting.

6. Replace the O-ring with a new one. See Fig. 68.

7. Carefully refit the cover. Be sure to lower the cover straight down the last 10 centimeters above the upper flange. See Fig. 69.

8. Refit the M12 bolts and washers to the top cover. See Fig. 66.
9. Tighten the bolts. Tightening torque 84 ±10 %.
10. Refill the oil; see Section 3.5.

If there is still oil leakage, check if the leakage is between the bevel gear flange and the tap-changer. Follow this procedure:

If the leakage is in the gear box (from the tap-changer into the gear box), contact ABB for further instructions.

11. Be sure that the oil level in the tap-changer is lowered by 100-150 mm.
12. Loosen the hose clip on the protective tube at the bevel gear. See Fig. 70.
13. Push the protective tube aside.
14. Remove the bevel gear. See Fig. 71.

Be sure not to twist the horizontal drive shaft.

15. Refit the bevel gear on the tap-changer cover.

Once the bevel gear is back in place, it is important to check that the vertical drive shaft has not been disturbed. Synchronize the shaft as described in section 4.1.

16. Check that the position indicator in the motor-drive mechanism (Fig. 59) shows the same position as the indicator inside the top-cover of the tap-changer (Fig. 60).

**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.

17. Refit the protective tube with the greater diameter upwards, facing the bevel gear. See Fig. 55.
18. Secure the hose clip on the protective tube facing the bevel gear. See Fig. 56.

**7.3 Replacement of pressure relay**

If the pressure relay fails to pass the insulation test and/or the function test, it must be replaced. This is described in the assortment guide.

**CAUTION**

It is not permitted to only replace the microswitch inside the pressure relay.
8. Electrical diagrams

On the following pages, the standard circuit diagrams and the contact timing diagrams for BUE and BUL2 are shown.

Be sure to use the circuit diagram and the contact timing diagram delivered with your tap-changer.
8.1 Standard circuit diagram BUE

SUPPLY FOR MOTOR  SUPPLY FOR HEATER  SUPPLY FOR CONTROL CIRCUIT

1) CONTINUATION CONTACT INCLUDED ONLY WHEN THE TAP-CHANGER HAS THROUGH-POSITIONS. CLOSED WHEN THE TAP-CHANGER IS AT THROUGH-POSITIONS.
8.2 Contact timing diagram BUE

<table>
<thead>
<tr>
<th>TURNS ON HAND CRANK FOR MOTOR-DRIVE MECHANISM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTACT</td>
</tr>
<tr>
<td>PERIOD</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1-2</td>
</tr>
<tr>
<td>3-4</td>
</tr>
<tr>
<td>5-6</td>
</tr>
<tr>
<td>7-8</td>
</tr>
<tr>
<td>9-10</td>
</tr>
<tr>
<td>11-12</td>
</tr>
<tr>
<td>13-14</td>
</tr>
<tr>
<td>15-16</td>
</tr>
</tbody>
</table>

### Control Elements

- **E1**: Anti-condensation heater
- **E3**: Cabinet light
- **K1**: Contactor, step-by-step operation
- **K2**: Contactor, raise
- **K3**: Contactor, lower
- **K6**: Time relay, run-through protection
- **M1**: Motor
- **Q1**: Motor protective switch
- **S1**: Control selector switch
- **S2**: Control switch
- **S5**: Interlocking switch, open when hand crank is fitted
- **S6**: Cam switch (limit switch)
- **S8**: Pushbutton, EMERGENCY STOP
- **S9**: Switch, door operated
- **S11**: Cam switch
  - 1-2 Starting contact, 3-4 Auxiliary contact
- **S12**: Cam switch
  - 1-2, 3-4 Holding contact
  - 5-6, 7-8 Interlocking contact
  - 9-10, 11-12 Auxiliary contact
  - 13-14, 15-16 Auxiliary contact
- **S14**: Position transmitter (potentiometer)
- **S15**: Continuation contact
- **X**: Terminal board group

### Symbols

- **Raise operation**: ⬆️
- **Lower operation**: ⬇️
- **Upper limit pos.**: ✡️
- **Lower limit pos.**: ⬇️
- **Remote control**: 🔄
- **Local control**: 🔄
- **Protective earth**: ⚡️
- **Crank**: 🔫
8.3 Standard circuit diagram BUL2

1) CONTINUATION CONTACT INCLUDED ONLY WHEN OLTC HAS THROUGH-POSITIONS. CLOSED WHEN OLTC IS AT THROUGH-POSITIONS.

2) REMOVE CONNECTION X4-1-2 TO DISABLE STEP-BY-STEP FUNCTION AND X3-11-12 TO DISABLE THE RELAY K601 (RUN-THROUGH PROTECTION).
8.4 Contact timing diagram BUL2

- **B1**: Thermostat
- **E1**: Anti-condensation heater
- **E2**: Heater
- **E3**: Lamp
- **F1**: Circuit breaker, heater circuit
- **F2**: Circuit breaker, control circuit
- **K1**: Contactor, step-by-step operation
- **K2**: Motor contactor
- **K3**: Motor contactor
- **K601**: Time relay, running-through protection
- **K602**: Time relay, tap change incomplete
- **M1**: Motor
- **Q1**: Protective motor switch
- **S1**: Control selector switch
- **S2**: Control switch
- **S3/S4**: Cam operated contacts
  - 33-34 Maintaining contact
  - 41-42 Interlocking contact
  - 13-14, 21-22 Auxiliary contact
- **S5**: Interlocking switch, open when hand crank is fitted
- **S6/S7**: Limit switch, upper/lower limit position
- **S8**: Pushbutton, EMERGENCY STOP
- **S9**: Switch, door operated
- **S14**: Position transmitter (potentiometer)
- **S15**: Continuation contact
- **U5**: Power supply unit, 100-240 V AC / 24 V DC
- **X**: Terminal board group
- **X3x**: Internal terminal board group

**Diagram Elements**

- **n → n+1**: 1 tap
- **n → n-1**: 1 tap
- **U**: Upper limit-position
- **L**: Lower limit-position
- **LOCAL control**
- **REMOTE control**
- **PE**: Protective ground
- **Crank**
9. Technical data

9.1 Dimensions

Fig. 73. VUBB dimensions.

9.2 Weights

The approximate weight of the VUBB tap-changer is specified below. The specified weights do not include the weights of the motor-drive mechanism and the drive shaft system.

Tap-changer without oil............. 280 kg
Weight of required oil............... 270 kg
Total weight....................... 550 kg

9.3 Specification of materials

CAUTION

Materials listed in the tables below, without any specification of amount, are included because they may cause pollution problems during decommissioning, even in the small quantities used.

9.3.1 General

Upon disposal of this product, compliance with the local environmental regulations of each country is recommended. The materials used are specified for environmental reasons.

9.3.2 Tap-changer housing

<table>
<thead>
<tr>
<th>Material</th>
<th>Approximate amount (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>95</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>46.8</td>
</tr>
<tr>
<td>Copper</td>
<td>36</td>
</tr>
<tr>
<td>Epoxy resin</td>
<td>13.2</td>
</tr>
<tr>
<td>Steel</td>
<td>6</td>
</tr>
<tr>
<td>Nitrile rubber</td>
<td>0.5</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>0.3</td>
</tr>
<tr>
<td>Glass</td>
<td>0.16</td>
</tr>
<tr>
<td>Brass</td>
<td>0.02</td>
</tr>
<tr>
<td>Silver</td>
<td>0.01</td>
</tr>
</tbody>
</table>

9.3.3 Selector switch

<table>
<thead>
<tr>
<th>Material</th>
<th>Approximate amount (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>108</td>
</tr>
<tr>
<td>Copper</td>
<td>62</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>49.6</td>
</tr>
<tr>
<td>Steel</td>
<td>36</td>
</tr>
<tr>
<td>Epoxy resin</td>
<td>13.2</td>
</tr>
<tr>
<td>Ceramics</td>
<td>6.15</td>
</tr>
<tr>
<td>Brass</td>
<td>3</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>3</td>
</tr>
<tr>
<td>Polyester resin</td>
<td>2.5</td>
</tr>
<tr>
<td>Polyphthalamide</td>
<td>2.5</td>
</tr>
<tr>
<td>Chrome</td>
<td>1</td>
</tr>
<tr>
<td>Nitrile rubber</td>
<td>0.5</td>
</tr>
<tr>
<td>Glass</td>
<td>0.2</td>
</tr>
<tr>
<td>Polyamide</td>
<td>0.06</td>
</tr>
<tr>
<td>Bakelite</td>
<td>0.04</td>
</tr>
<tr>
<td>Silver</td>
<td>0.03</td>
</tr>
<tr>
<td>PTFE</td>
<td>0.02</td>
</tr>
</tbody>
</table>
### 9.3.4 Gearing mechanism

<table>
<thead>
<tr>
<th>Material</th>
<th>Approximate amount (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>21</td>
</tr>
<tr>
<td>Brass</td>
<td>1.3</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>1</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.1</td>
</tr>
</tbody>
</table>

### 9.3.5 Drive shaft system

<table>
<thead>
<tr>
<th>Material</th>
<th>Approximate amount (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>10.1</td>
</tr>
</tbody>
</table>
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