Original instruction
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# 1. Safety

## 1.1 General
This user’s guide must be read and understood, and 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 parts of the diverter switch, the insulating oil and the motor-drive mechanism.

Notice
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.

Notice
After a pressure relay trip, contact ABB. The tap-changer housing must be drained and the diverter 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.

The electrical circuit principle for the VUCG is shown in Figs. 1-8, and for VUCL in Figs. 9-20. The purpose of the operation is to commute the load from one tap to the other in order to change the voltage.

The figures on the following pages show the contact sequence along with the physical position of the interrupter.
2.3 Switching sequence, VUCG

By using an auxiliary contact system (MC, RC) in combination with the vacuum interrupters (MVI, RVI) only two vacuum interrupters are required per phase.

Fig. 1 shows the current path during normal operation, from x to the star point (could also be to the next phase).

When commuting the load from x to v, the first part of the operation sequence is to open the main vacuum interrupter (MVI) and hence let the current flow through the transition resistor (TR), Fig. 2.

The main contact (MC) is then rotated (Figs. 3 and 4) in order to connect to v.
The main vacuum interrupter then closes, leading to an associated circulating current driven by the difference in voltage potential, Fig. 5. The load current is now via the normal path from v to the star point.

In Fig. 6, the transition resistor is disconnected when opening the resistor vacuum interrupters (RVI).

The resistor contact (RC) is then rotated and put in position according to Fig. 7.

Finally, the sequence is completed and next service position is reached when the resistor vacuum interrupter is closed, see Fig. 8.
2.4 Switching sequence, VUCL

By using an auxiliary contact system (MC, RC) in combination with the vacuum interrupters (MVI, RVI) only two vacuum interrupters are required per phase.

Fig. 9 shows the current path during normal operation, from x to the star point (could also be to the next phase).

When commuting the load from x to v, the first part of the operation sequence is to open the bypass contact (BPC), Figs. 10 and 11.

Next is to open the main vacuum interrupter (MVI) and hence let the current flow through the transition resistor (TR), Fig. 12.
The main contact (MC) is then rotated (Figs. 13 and 14) in order to connect to \( v \).

The main vacuum interrupter then closes, leading to an associated circulating current driven by the difference in voltage potential, Fig. 15.

The load current now goes from \( v \). The bypass contact is then connected to \( v \) (Figs. 16 and 17).
In Fig. 18, the transition resistor is disconnected when opening the resistor vacuum interrupters (RVI). The load current is now via the normal path from v to the star point. The resistor contact (RC) is then rotated (Fig. 19) and makes the v-side. Finally, the sequence is completed and next service position is reached when the resistor vacuum interrupter is closed, see Fig. 20.
2.5 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 VUC tap-changers are 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. 21.

Yoke-mounting means that the tap-changer is temporarily placed on a fork located on the active part of the transformer. See Fig. 22. 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-changers type VUC can be switched using:
- Linear switching, see Fig. 23.
- Plus/minus switching, see Fig. 24.
- Coarse/fine switching, see Fig. 25.

The general arrangement of a tap-changer system can be executed using:
- Three-phase, star point connection, see Fig. 26.
- Single-phase, see Fig. 27.
- Three-phase delta, see Fig. 28.
- Three-phase delta, fully insulated connection, see Fig. 29.
- Auto transformer, see Fig. 30.
2.5.1 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.
2.5.2 Type of connection

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

Single-phase (E)
Only one unit is required.

Three-phase delta (B)
Two units required. Driven by a common motor-drive. One unit common for two phases.

Three-phase delta fully insulated (T)
Three units required. Driven by a common motor-drive.

Auto transformer (T)
Several configurations of auto transformers exist. This example shows the tap-changer in auto-tap.
2.6 Diverter switches
The diverter switches with vacuum interrupters are of the high-speed, spring-operated type with resistors as transition impedance. They are equipped with plug-in contacts that automatically connect to the bushings in the diverter switch housing when the switch is lowered into the housing. Guiding facilities keep the diverter switch in the correct position when lowering it into the housing. Mechanical coupling to the motor-drive mechanism is automatically established when the driving pin enters the slot in the driving disc.

The design and dimensioning of the diverter switches offer high reliability and long life with a minimum of maintenance and easy inspection.

Diverter switches with vacuum interrupters combine all the advantages of the conventional type with improved breaking capacity, increased contact life and reduced maintenance.

The switch works according to the pennant cycle, which gives the lowest complexity and allows full power flow in both directions. A mechanical rectifier ensures operation in only the direction that gives the lowest breaking stresses and contact wear, independently of RAISE or LOWER command.

The load is commutated from one tap to the other with the aid of the vacuum interrupters and auxiliary contacts. The auxiliary contacts are also able to break the load current in the unlikely event that a vacuum interrupter failure should occur. For VUCG in service position, the load current is transferred through the auxiliary contacts and the vacuum interrupters. All current carrying contacts are made of low resistance material. For VUCL in service position, the load current is transferred through a bypass contact.

The contact system is operated by a compact mechanical system with integrated driving springs, mechanical rectifier, robust mechanical system for vacuum interrupter actuating and geneva gears for operating the auxiliary contacts.

Most manufactured conventional UCG and UCL diverter switches can be easily replaced by the vacuum diverter switch and gain benefit from the improvements made on this type. The VUCG diverter switch fits in all UCG tap-changers as manufactured 1977 and later without modification, which enables all UCG tap-changers to be easily upgraded to vacuum technology. The VUCL diverter switch fits all UCL housings manufactured 1985 and later without modification.

2.7 Tap selectors
Although the tap selector for the VUC range of tap-changer is available in various sizes, all of them have similar functions with different ratings.

The fixed contacts are mounted around the central shafts. The moving contacts are mounted on, and are operated by, the shafts in the center of the selector. The moving contacts are connected, via current collectors, to the diverter switch by means of paper insulated copper conductors.

Depending on the load current, the moving contacts have either one, two, or more contact arms in parallel with one, two or four contact fingers each. The fingers make contact at one end with the fixed contact, and at the other with the current collector. The moving contacts slide on the fixed contacts and the current collector rings, giving a wiping action which makes the contacts self cleaning. This arrangement promotes good conductivity and negligible contact wear.

The tap selectors available for the VUC range of tap-changers are C, III and F. Tap selector C can be combined with VUCG diverter switches. Tap selector III and F can be combined with both VUCG and VUCL. All three tap selector types use a complete, un-divided glass fiber reinforced epoxy cylinder for the fine selector.
2.8 Design differences across the VUC range of on-load tap-changers
The VUC range of tap-changers consists of two diverter switches and two tap selectors.

The diverter switches are VUCG and VUCL. Both have arc quenching in vacuum interrupters. In VUCG the load current goes continuously through the vacuum interrupters, while VUCL has a by-pass contact for the load current when not operating.

The tap selectors available are C, III and F. VUCG is possible to combine with all three, while VUCL can be combined with tap selector III or F.

2.9 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.

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

2.11 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.

2.12 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.

2.13 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.

2.14 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.
ON-LOAD TAP-CHANGERS TYPE VUC OVERVIEW (VUCG Shown)
2.15 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.

<table>
<thead>
<tr>
<th>ABB AB</th>
<th>Components, Ludvika</th>
<th>Motor-drive mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>On-load tap changer</td>
<td>Motor-drive mechanism</td>
<td></td>
</tr>
<tr>
<td>No. 1250</td>
<td>Motor supply</td>
<td>V</td>
</tr>
<tr>
<td>A Step voltage</td>
<td>Hz</td>
<td>Contactor</td>
</tr>
<tr>
<td>Transition resistance</td>
<td>ohm</td>
<td>Position transmitter</td>
</tr>
<tr>
<td>Estimated contact life</td>
<td>sec</td>
<td>Heating element</td>
</tr>
<tr>
<td>operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standards IEC 60214-1 (2003-02)</td>
<td>Year of manufacture</td>
<td></td>
</tr>
<tr>
<td>Maintenance after 300,000 operations (guideline: 15 years). Inspection once a year.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Energize the heater when power is available. When not, pull drying agent inside the motor drive cabinet and seal the vents.

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32 Example of rating plate.

---

33 Location of serial number plate and rating plate.
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:

- Standard set of open-end wrenches (up to 19 mm)
- Standard set of combination spanners
- Thickness guide up to 4.5 mm and accuracy 0.1 mm
- Ohmmeter
- Air pump with hose, pressure gauge (0-250 kPa) and connection with internal thread R 1/8"
- Telpher (170 kg lifting force)
- Empty and clean barrels for transformer oil (calculate with max. 400 l for each diverter switch housing)
- Oil draining and filtering equipment with connections
- Test equipment according to IEC 60156
- Two buckets (approximately 10 l)
- Rags (lint-free)
- 50 l of new transformer oil (Oil I -30 °C according to IEC 60296).
- Oil of same brand and type for replacing the existing oil in the tap-changer compartment.
- Protective gloves, oil proof
- Dimension drawing for the tap-changer
- Pen and note pad
- Maintenance guide
- New O-ring (540 x 8) for the cover
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 sampling valve on the tap-changer.
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. 34.
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. 35.
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.

For standard shaft arrangements, the maximum angle (totally in two directions) is 4°. For larger angles, order design is required.

For single units (VUC..E, N) the gear box of the tap-changer might be mounted in the angle given in Fig. 36. The angle is given when ordering.

**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° = 70 mm for every 1000 mm of shaft length.)

   [Permitted range: 0° to -10° and 190° to 200°]

   ![Permitted range diagram](36 Mounting angle, single unit)

   Protective tubes with slotted ends must be used. 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. 37.

3. Fit six screws and washers in the holes on the coupling halves. See Fig. 38.

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

   ![Fit coupling halves and screws](37 Fit two coupling halves on the square shaft)

   ![Fit screws and washers](38 Fit screws and washers to the coupling halves)

   ![Tighten outer screws](39 Tighten the two outer screws)
5. Tighten the two outer screws. Tightening torque 10 Nm ±10 %. See Fig. 39.
6. Tighten the remaining screws crosswise with the same tightening torque. See Fig. 40.
7. Position the two protective tubes with the slotted ends outwards. See Fig. 41.
8. Fit two hose clips. See Fig. 42.
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. 37. Be sure to offset these coupling halves 90° in relation to the couplings mounted in step 2. See Fig. 43.
12. Fit six screws and washers in the holes on the coupling halves (see Fig. 38) and lightly tighten them.
13. Check that the axial play is no more than 2 mm. See Fig. 44. If necessary, adjust the axial play by operating the couplings on the shaft end.
14. Tighten the outer two screws; see Fig. 39. Tightening torque 10 Nm ±10 %.
15. Tighten the remaining screws crosswise (see Fig. 40) with the same tightening torque.
16. Push the two protective tubes horizontally until they touch the bevel gears. See Fig. 45.

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

17. Clamp the protective tubes with the hose clips. See Fig. 46.
18. Apply the self-adhesive information plates around the tubes at about the middle of the tube length. See Fig. 47.
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. 48.
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. 49.
5. Tighten the two outer two screws. Tightening torque 10 Nm \(\pm 10\%\). See Fig. 50.
6. Tighten the remaining screws crosswise with the same tightening torque. See Fig. 51.
7. Connect the shaft with the mounted coupling halves to the shaft of the bevel gear. See Fig. 52.
8. Place the two protective tubes on the vertical drive shaft. See Fig. 53.
9. Fit two hose clips. See Fig. 54.
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. 55.
11. For BUE motor-drive mechanism, loosen the two screws on the multi-hole coupling inside the motor-drive mechanism. See Fig. 56.
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. 48. Be sure to offset these coupling halves 90° in relation to the couplings mounted in step 2 as shown in Fig. 57.

14. Connect the bottom end of the square shaft with the mounted coupling halves to the shaft of the motor-drive mechanism. See Fig. 58.

15. Fit six screws and washers in the holes on the coupling halves (see Fig. 49) and tighten them lightly.

16. Check that the shaft cannot be moved more than 2 mm in the axial direction (axial play). See Fig. 59. If necessary, adjust the axial play by moving the couplings on the shaft end.

17. Tighten the two outer screws; see Fig. 50. Tightening torque 10 Nm ±10%.

18. Tighten the remaining screws crosswise (see Fig. 51) with the same tightening torque.
19. Place the protective tube with the greater diameter upwards, facing the bevel gear. See Fig. 60.
20. Secure the tube with a hose clip. See Fig. 61.
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. 62.

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. 63.

To access the position indicator, remove the cover. See Fig. 65.

60 Place the protective tube with the greater diameter upwards.

61 Fit a hose clip.

62 BUL: Cam disc and roller on the brake arm.

62 BUE: Red mark on the brake disc.
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. 64) and the tap-changer (Fig. 65) 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.
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. 64 and Fig. 65.

**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. 65.

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 $11.5 \pm 1$ turn of the hand crank.
   - For BUE – the tap-changer should operate after $19 \pm 1.5$ 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. 64.
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 BUL:
7. Run the motor-drive mechanism.
8. Check that the center of the notch in the cam disc stops within $\pm 2$ mm of the center of the roller on the brake arm. See Fig. 62.

   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. 64.

   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
13. 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. 64 and 65.

**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. 65.
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.

3.8 Energizing
The tap-changer can now be energized and commissioned.

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

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

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.

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.

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.

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

**WARNING**
Small amounts of explosive gases are constantly discharged from the breathing devices (dehyrdrating 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.

### 4.1 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. 66.

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. 55 (BUL) and 56 (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. 67.

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

6. Make sure that the clearance at the bottom of the tube is between 3 and 5 mm. See Fig. 68.

7. Secure the tube with the hose clip. See Fig. 69.
5. Inspection

The VUC 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. See Table 1.

**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.
5.3 Oil sampling
When an oil sample is to be taken (Table 1), it is recommended to do so in time before a planned stop. Maintenance may be necessary based on the test results. The test results should be documented.

Before starting any work, the section referring to oil testing and oil draining should be read and fully understood.

**WARNING**
When opening the valve, large amounts of oil can come out from the tap-changer. Be ready to close the valve when enough oil has been removed.

**Table 1. Recommended inspection and maintenance schedule.**

<table>
<thead>
<tr>
<th>Time or number of operations</th>
<th>Inspection</th>
<th>Oil sampling</th>
<th>Maintenance (see also section 5.4)</th>
<th>End of life</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yearly</td>
<td>After 2, 6, 11 and 15 years</td>
<td>300 000 operations</td>
<td>600 000 operations</td>
</tr>
<tr>
<td>Type of action</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check oil level at conservator</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Check the breather</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Visual check of motor-drive mechanism</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Test of oil quality (IEC 60422, 2005-10)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Dissolved gas analysis (DGA)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Measure the transition resistors</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Cleaning the diverter switch and housing</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Oil filtration or replacement</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Measure the wear of the vacuum interrupters</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Inspection of check points</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Replacement of vacuum diverter switch</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacement of diverter switch and housing</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacement of tap selector</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Recommended tools:
- Protective gloves
- Oil sampling container
- Test equipment according to IEC 60156 (breakdown voltage)
- Test equipment according to IEC 60475 (sampling insulation liquids)
- Pen and note pad

**5.3.1 Conservator**
It is recommended to have enough oil in the conservator to allow for oil samples to be taken, until the first maintenance stop, without adding any new oil.

The conservator for vacuum type tap-changers shall be 15 liters larger than a conventional tap-changer conservator.

Material to take oil and gas samples can be ordered from ABB. Included in the box is also an instruction how to perform the test. (If other laboratory is used the instruction may not exist).

When taking oil samples, please note that the oil level in the conservator is lowered as the oil volume decreases.
5.3.2 Sampling procedure for tap-changers

- Open the sample valve and remove at least the volume of the tube between the diverter switch housing and the valve, plus one extra liter. See Fig. 70.
- Use a clean container when taking the oil sample for testing.
- Use the appropriate method stated in IEC 60475 and IEC 60422

Plastic bottles should not be used for DGA and dielectric breakdown, since the plastic can affect the result. If plastic bottles are used, they must be compatible to oil.

For further information about transportation and storage, see IEC 60475.

5.3.3 Information about the sample

At least following data should be taken and sent together with the result to ABB:

<table>
<thead>
<tr>
<th>Transformer and tap-changer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
</tr>
<tr>
<td>Transformer manufacturer</td>
</tr>
<tr>
<td>Identification number of the transformer</td>
</tr>
<tr>
<td>Type of transformer</td>
</tr>
<tr>
<td>Type of tap-changer</td>
</tr>
<tr>
<td>Serial number of the tap-changer</td>
</tr>
<tr>
<td>Type of liquid</td>
</tr>
</tbody>
</table>

Sampling

<table>
<thead>
<tr>
<th>Sampling date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling occasion after commissioning</td>
</tr>
<tr>
<td>Oil temperature</td>
</tr>
</tbody>
</table>

5.4 Maintenance

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

Depending on the application, load and environment, it is recommendable to perform one maintenance (cleaning and inspection) during the transformer life. The figure of 15 years stated on the rating plate is provided as a guideline.

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.
6. 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 diagrams delivered with your tap-changer.

6.1 Standard circuit diagram BUE

On the following pages, the standard circuit diagrams and the contact timing diagrams for BUE and BUL2 are shown. Be sure to use the diagrams delivered with your tap-changer.

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

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
6.3 Standard circuit diagram BUL2

1) Continuation contact included only when OLTC has through-positions. Closed when OLTC is at through-positions.

2) Remove connection X4.2-2 to disable step-by-step function and X3.11-12 to disable the relay K601 (run-through protection).
6.4 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
- **F33-F34**: Maintaining contact
- **F41-F42**: Interlocking contact
- **F13-F14, F21-F22**: 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 Notes**

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

7.1 Dimensions
Dimensions are available in the Technical guide and at the dimension drawings.

7.2 Weights
The weights of the tap-changer are available in the Technical guides and in the Installation and commissioning guides.

7.3 Specification of materials

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

7.3.1 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.

7.3.2 Diverter switch housing

<table>
<thead>
<tr>
<th>Material, approximate amount (kg)</th>
<th>VUCG</th>
<th>VUCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>Aluminium</td>
<td>75</td>
<td>80</td>
</tr>
<tr>
<td>Copper and alloys</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Epoxy resin</td>
<td>35</td>
<td>60</td>
</tr>
<tr>
<td>Transformer oil</td>
<td>200</td>
<td>300</td>
</tr>
</tbody>
</table>

7.3.3 Diverter switch

<table>
<thead>
<tr>
<th>Material, approximate amount (kg)</th>
<th>VUCG</th>
<th>VUCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>15.2</td>
<td>27</td>
</tr>
<tr>
<td>Steel</td>
<td>27.3</td>
<td>36</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>0.12</td>
<td>1.2</td>
</tr>
<tr>
<td>Copper and alloys</td>
<td>14.2</td>
<td>24</td>
</tr>
<tr>
<td>Brass</td>
<td>4.8</td>
<td>6</td>
</tr>
<tr>
<td>Polyester resin with glass</td>
<td>7.12</td>
<td>13</td>
</tr>
<tr>
<td>Tungsten</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>0.022</td>
<td>-</td>
</tr>
<tr>
<td>Silver</td>
<td>-</td>
<td>0.16</td>
</tr>
<tr>
<td>Chrome</td>
<td>0.24</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Resistor wire (mainly copper and nickel alloys with small amounts of aluminium, magnesium and chrome) 4-45 4-45

7.3.4 Tap selector

<table>
<thead>
<tr>
<th>Material, approximate amount (kg)</th>
<th>Tap selector C</th>
<th>Tap selector III</th>
<th>Tap selector F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>5</td>
<td>10</td>
<td>113</td>
</tr>
<tr>
<td>Aluminium</td>
<td>15</td>
<td>40</td>
<td>94.5</td>
</tr>
<tr>
<td>Copper and alloys</td>
<td>20</td>
<td>50</td>
<td>52</td>
</tr>
<tr>
<td>Silver</td>
<td>70</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Phenol resin laminate</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Polyester resin</td>
<td>5</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Epoxy resin</td>
<td>15</td>
<td>20</td>
<td>46</td>
</tr>
</tbody>
</table>

7.3.5 Conductors

<table>
<thead>
<tr>
<th>Material, approximate amount (kg)</th>
<th>VUCG</th>
<th>VUCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>5-10</td>
<td>5-20</td>
</tr>
<tr>
<td>Cellulose</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.3.6 Gearing mechanism

<table>
<thead>
<tr>
<th>Material, approximate amount (kg)</th>
<th>VUCG</th>
<th>VUCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Copper and alloys</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

7.3.7 Drive shaft systems

<table>
<thead>
<tr>
<th>Material, approximate amount (kg)</th>
<th>VUCG</th>
<th>VUCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Aluminium</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Brass</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>