On-load tap-changer, type VUCG

Maintenance guide
**Recommended practices**

ABB recommends careful consideration of the following factors for maintenance work on safety devices:

Before you start any work, make sure that the personnel doing the job have read and fully understood the documents provided with the unit.

To avoid damaging the unit, never exceed the operating limits stated in delivery documents and on rating plates.

Do not alter or modify a unit without first consulting ABB.

Follow local and international wiring regulations at all times.

Use only factory authorized replacement parts and procedures.

**WARNING, CAUTION and NOTE**

**WARNING**

A WARNING provides information which, if disregarded, could cause injury or death.

**CAUTION**

A CAUTION provides information which, if disregarded, could cause damage to the equipment.

**NOTE:** A NOTE provides additional information to assist in carrying out the work described.

**Safety precautions**

**WARNING**

The Maintenance Guide should be read and understood before any work is started, and the procedures in this document should be followed at all times.

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

Before carrying out work on the on-load tap-changer, put the LOCAL/REMOTE switch in the motor-drive mechanism to position 0. It is also recommended to shut the door of the motor-drive mechanism and pad lock it when work is carried out on the on-load tap-changer. The key should be kept by the service technician. This is done to avoid unexpected start of the motor-drive mechanism.

Before starting any work inside the motor-drive mechanism, the auxiliary power must be switched off.

N.B. The motor, contactors and heating element may be energized from separate sources.

In no case should any person go down into the diverter switch housing. The cleaning of the diverter switch housing should be carried out by using brushes and rags and by flushing with oil.
CAUTION
Approval should be given for inspection as well as for operating the on-load tap-changer.

ABB recommends that only maintenance engineers trained by the manufacturer carry out replacement of the vacuum interrupters.

During service

WARNING
Small amounts of explosive gases might come out from the breathing devices (dehydrating breather or one-way breather). Make sure that no open fire, hot surfaces or sparks occurs in the immediate surroundings of the diverter switch or the breathing devices.

If a failure in power supply occur during operation, the operation will be completed when the power returns.

The hand crank must not be inserted during electrical operation.

If the on-load tap-changer is not in 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.

CAUTION
After a pressure relay trip, follow the instructions in section “Trip or alarm from supervisory devices” in the User’s Manual.

During oil handling

WARNING
Unused transformer oil is slightly harmful. Fumes from unused warm oil may irritate the respiratory organs and the eyes. After long and repeated contact with transformer oil skin becomes very dry.

Used on-load tap-changer oil from diverter switch housings and selector switch housings contains harmful substances. Fumes are irritating to the respiratory organs and the eyes and are highly flammable. Used transformer oil may well be carcinogenic.

Avoid contact with the oil as much as possible and use oil-tight protective gloves when handling the oil.

First aid:
Skin contact: Wash the hands. Use skin cream to counteract drying.
In the eyes: Rinse the eyes in clean water.
Swallowing: Drink water or milk. Avoid vomiting. Call a doctor.

Collect used oil in oil drums.

Waste and cleaning up: Should be absorbed by an absorber. Treat it as hazardous to the environment.

Upon fire: The fire should be extinguished by using powder, foam or carbon acid.
WARNING
When oil that has been used in a selector switch compartment is pumped out, conducting tubes and hoses that are earthed should be used to avoid the risk of explosion due to gases produced by the arcs during service.

The oil in the selector switch compartment may be hot. Be cautious!

There might be a cushion of explosive gases in the top of the diverter switch housing. No open fire, hot surfaces or sparks may be present during opening of the housing or draining from the valve. After the cover is removed let the gas vent away approximately 15 min before any work is started.

Be aware of the risk of slipperiness caused by oil spillage for instance when working on the transformer cover.

CAUTION
Take care to avoid ingestion of moist air when oil is drained. If the ambient air is moist, let incoming air pass through a dehydrating breather with slow air flow to obtain proper dehy- dration.

Do not fill oil into the on-load tap-changer if the transformer tank is under vacuum and the on-load tap-changer is not.

Do not fill oil into the transformer tank if the on-load tap-changer is under vacuum and the transformer tank is not.

After oil filling

CAUTION
Do not energize the transformer earlier than three hours after oil filling in atmospheric pressure. This waiting period is needed to allow air bubbles to disappear.

Mounting of gaskets

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 as described in section 1.3 Tightening Torque, in this guide.
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1. Introduction

1.1 General

VUCG has been developed over a long period in order to give time for excessive testing, both mechanically and electrically, as well as field testing. All this is made to give a maximum reliability to the product. The simple and robust design gives a service life equal to the service life of the transformer in most applications. Minimum maintenance is required for trouble-free operation. The only parts requiring maintenance are the vacuum interrupters that might need replacement during the service life, the insulating oil and the motor-drive mechanism.

The design allows excellent access to all parts, making inspection and maintenance quick and simple.

The on-load tap-changer, type VUCG, is housed in the transformer tank. The motor-drive mechanism is attached to the transformer tank and connected to the on-load tap-changer by means of drive-shafts and a bevel gear, see Fig. 1.

![Diagram of on-load tap-changer and motor-drive mechanism]

**Fig. 1.** On-load tap-changer and motor-drive mechanism.
Fig. 2. General arrangement of on-load tap-changer, type UC.
Fig. 2 shows the general arrangement of an on-load tap-changer type UC. The main components are the spring-operated diverter switch and the tap selector with sliding contacts. For maintenance the diverter switch is lifted. The vacuum interrupters are immediately accessible and can be inspected for wear. The drive-shafts should not be dismantled when lifting the diverter switch.

Maintenance is normally not required on the parts operating in the oil of the transformer tank. However, when the on-load tap-changer has made 1.5 million operations, the tap selector shall be replaced.

The diverter switch has its own housing separate from the transformer oil to prevent contamination. The oil is checked according to the recommendations in IEC 60422.

The main components of the diverter switch are:

- Plug-in contacts
- Main contact system including vacuum interrupters
- Resistor contact system including vacuum interrupters
- Transition resistors
- Spring-drive mechanism

Besides the maintenance of the diverter switch and cleaning of the oil, the motor-drive mechanism should be checked and lubricated.

The protective device that protects the transformer from damage due to excessive pressure in the diverter switch housing, should also be checked.

NOTE: One on-load tap-changer of VUCG type may consist of one, two or three units driven by a common motor-drive mechanism. The instructions in this guide deal with one unit. If there are two or three units, all work described should be carried out on all units unless otherwise stated. If more than one diverter switch is lifted out at the same time, make sure the right diverter switch is lowered into the right housing (compare with the serial numbers, given on the top of the diverter switch housing and on the frame of the diverter switch).

1.2 Maintenance schedule

Maintenance of the on-load tap-changer consists of three major levels:

- Inspection
- Overhaul
- Replacement of vacuum interrupters

1.2.1 Inspection

On the rating plate, “inspection once a year” is recommended. This principally concerns the motor-drive mechanism and refers to a visual inspection inside the motor-drive cabinet to check that nothing is loose and the heater is functioning.

In the motor-drive mechanism a counter registers every tap-changer operation. During inspection the counter is read. If possible, motor and counter are tested by operating one step and then back.

If the on-load tap-changer has its own oil conservator, the breather and the oil level indicator are checked according to the instructions from the transformer manufacturer.

The inspection is carried out while the transformer is in service.
1.2.2 Overhaul

The frequency of operations or the time in service determines the time interval between overhauls.

The number of operations run by the on-load tap-changer is recorded by a counter, housed in the motor-drive mechanism cabinet. The registered number of operations should be noted at every inspection and overhaul.

The on-load tap-changer should normally be overhauled regularly at intervals of 150,000 operations. The relevant information is stated on the rating plate. Hereby, the mechanical integrity can be confirmed and the contact wear can be followed, and the necessary preparations can be made for replacing the vacuum interrupters.

If the tap-change operations occur infrequently and a very long time elapses until the 150,000 operations, the interval between overhauls should be limited to the time stated on the rating plate (normally 15 years).

1.2.3 Replacement of vacuum interrupters

On the rating plate of the on-load tap-changer the estimated contact life of the vacuum interrupters in the diverter switch at rated load is stated.

For actual load currents up to 600 A for VUCG.N, B and up to 1000 A for VUCG.E, T it is normally not necessary to replace the vacuum interrupters during the life of the diverter switch. For actual load currents above those values, the vacuum interrupters shall be replaced after 500,000 operations.

CAUTION
The number of operations must not exceed 1,000,000, which is the mechanical lifetime of the diverter switch.

1.3 Tightening torque

The following tightening torques are recommended for metallic screw joints:

<table>
<thead>
<tr>
<th>Size</th>
<th>Torque (Nm)</th>
<th>±10 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>M6</td>
<td>10</td>
<td>±10 %</td>
</tr>
<tr>
<td>M8</td>
<td>24.5</td>
<td>±10 %</td>
</tr>
<tr>
<td>M10</td>
<td>49</td>
<td>±10 %</td>
</tr>
<tr>
<td>M12</td>
<td>84</td>
<td>±10 %</td>
</tr>
</tbody>
</table>

for non-metallic screw joints:

<table>
<thead>
<tr>
<th>Size</th>
<th>Torque (Nm)</th>
<th>±10 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>M10</td>
<td>9</td>
<td>±10 %</td>
</tr>
<tr>
<td>M12</td>
<td>13</td>
<td>±10 %</td>
</tr>
<tr>
<td>M16</td>
<td>22</td>
<td>±10 %</td>
</tr>
</tbody>
</table>

if not otherwise stated in this guide.
2. Inspection

The inspection mainly consists of a visual check of the motor-drive mechanism and the conservator once a year while the transformer is in service. See the relevant guides for more information.

In the motor-drive mechanism the following points are to be checked:

- Motor and counter
- Heater
- The counter’s value

Follow the instructions in the guides for the respective motor-drive mechanism.

On the conservator the following are to be checked:

- Oil level
- Breather

**CAUTION**

*Approval should be given for inspection as well as for operating the on-load tap-changer.*

**WARNING**

*This work must be carried out from ground level since the transformer is energized!*

*The breathers and the tube from the conservator might contain explosive gases. No open fire, hot surfaces or sparks may be present when loosening the breather.*

1. Check the breathers according to the instructions for the transformer.
2. Check the oil level in the conservator for the on-load tap-changer. The oil level should be according to the transformer documentation.
3. Overhaul

**WARNING**

Before any work is carried out on the on-load tap-changer:
Make sure that the transformer is disconnected and that earthing is properly carried out. Obtain a signed certificate from the engineer in charge.

### 3.1 Required tools and materials

Necessary for the overhaul of the tap-changer is the following equipment:
- Normal hand tools (keywidth up to 19 mm)
- Normal set of combination spanners
- Thickness guide up to 3 mm and accuracy 0.1 mm
- Ohmmeter
- Air pump with pressure gauge (0-200 kPa) and connection to R 1/8” male thread
- Telpher (at least 150 kg lifting force)
- Empty and clean barrels for transformer oil (calculate with max. 225 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 (non-fuzzing)
- 50 l of new transformer oil (Oil I -30 °C according to IEC 60296).
- Grease (GULF-718 EP synthetic grease, Mobilgrease 28, Shell-Aero Shell grease 22 or equivalent)
- Protective gloves, oil proof
- Dimension drawing for the on-load tap-changer
- Pen and note pad
- Maintenance guide
- New O-ring (435 x 8) for the cover

When measuring contact timing, equipment according to Appendix 1 shall be added.

When replacing the vacuum interrupters (see also section 3.9):
- Tools for torx T20, T25 and T30
- Torque wrench (25 Nm)
- Replacement set of vacuum interrupters.

### 3.2 Procedure

The overhaul procedure includes the following points:
- Oil testing and oil draining
- Lifting and cleaning the diverter switch
- Cleaning the diverter switch housing and the oil filter (if any)
- Oil filtration
- Checking the breathers
- Checking the wear of the vacuum interrupters
- Checking the transition resistors
■ Checking before lowering the diverter switch
■ Lowering the diverter switch
■ Checking the pressure relay
■ Lubrication
■ Checking the motor-drive mechanism
■ Oil filling
■ Check of contact timing
■ Putting into operation

3.3 Preparations

**NOTE:** If the on-load tap-changer is oil filled under atmospheric pressure, a waiting period of three hours is needed before energizing. To save out of service time of the transformer, carry out all work on the on-load tap-changer and the oil filling before the maintenance of the motor-drive mechanism is started.

3.3.1 On-load tap-changer position

Note the position of the on-load tap-changer to enable restart of the transformer in the right tap position.

3.3.2 Disconnection and earthing of the transformer

**WARNING**

Before starting any work in the on-load tap-changer the protective motor switch and the LOCAL/REMOTE switch must be set at 0.

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

3.3.3 Oil volumes and lifting heights

The necessary number of empty drums for collecting and filtering of the oil in the diverter switch housing should be kept ready. The drums must be carefully cleaned and free from water. New oil needed should be of class Oil I -30 °C according to IEC 60296.

Table 1.

<table>
<thead>
<tr>
<th>VUCG..</th>
<th>Quantity of oil in the diverter switch housing and lifting height for the diverter switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>380/...</td>
<td>Approx. 170 liters (lifting height 1.4 m)</td>
</tr>
<tr>
<td>650/...</td>
<td>Approx. 170 liters (lifting height 1.4 m)</td>
</tr>
<tr>
<td>1050/...</td>
<td>Approx. 205 liters (lifting height 1.7 m)</td>
</tr>
</tbody>
</table>

**NOTE:** The volume of the oil conservator is not included.

Alternatively, the oil may be replaced by new oil and the used oil filtered at some later occasion. A certain quantity of new oil, at least 50 liters, should be kept ready to replace waste oil and for cleaning.

**NOTE:** It is recommended to test the dielectric strength of both the old and the new oil. See Table 2.

**CAUTION**

*Do not energize the transformer until oil has been filled as per section 3.14 in this guide.*
3.4 Oil testing and oil draining

The diverter switch housing is equipped with an oil valve placed on the top section. For connection dimensions, see the dimension drawing for the on-load tap-changer.

**WARNING**
The oil in the diverter switch housing may be hot. Be cautious!

Take an oil sample from the oil tap and check that it fulfils the requirements for dielectric strength according to table 2. The sampling is carried out in order to check if there is right oil quality in the on-load tap-changer.

**Table 2.**

<table>
<thead>
<tr>
<th>On-load tap-changer</th>
<th>Dielectric strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>All star point and all BIL 380 kV</td>
<td>≥ 30 kV/2.5 mm</td>
</tr>
<tr>
<td>Others</td>
<td>≥ 40 kV/2.5 mm</td>
</tr>
</tbody>
</table>

1) Star point is an **N** as the fifth letter in the type designation and the BIL value is the first digits in the type designation on the rating plate. This is for star point and BIL 380 kV, for instance VUCG(N 380)/700.

If the oil shall be re-used after draining, it must always be filtered. See section Oil Filtration.

**NOTE:** When taking the oil-sample, first drain some oil into a bucket to clean the valve.

**NOTE:** There is a hole in the upper part of the draining tube to prevent air from being trapped inside the tube when oil filling. The air sucked in through this hole when draining might disturb the function of some types of pumps. In such a case, drain the oil using a hose instead.

**CAUTION**

Never block the hole in the draining tube!

It is recommended to remove the breathing device when draining the oil. Use the filtering equipment or the pump to drain oil from the on-load tap-changer into carefully cleaned oil drums. Connect the pump to the oil valve and drain the oil from the diverter switch housing and the breathing device. Draining can be effected quickly if filtering equipment is used and at the same time the whole oil quantity will be filtered once. Remove the cover of the diverter switch housing while draining.

**WARNING**

There might be a cushion of explosive gases in the top of the diverter switch housing. No open fire, hot surfaces or sparks may be present during opening of the housing or draining from the valve. After the cover is removed let the gas vent away approximately 15 min before any work is started.

When oil that has been used in a diverter switch housing is pumped out, conducting tubes and hoses that are earthed should be used to avoid the risk of explosion due to the gases produced during service.

Drain the remaining oil in the bottom of the housing by using a hose.
Fig. 3. Diverter switch, general arrangement
3.5 Lifting and cleaning the diverter switch

The weight of the diverter switch is approximately 115 kg.

Lift the diverter switch partly so you can flush it with oil. After careful flushing, lift the diverter switch from the housing. Lift according to Fig. 4.

**CAUTION**

*When lifting the diverter switch, use a manually operated telpher to avoid damages on the diverter switch. Make sure that all parts of the diverter switch are kept clear of the inner edge of the flange.*

**WARNING**

The vacuum interrupters are sensitive devices and the diverter switch shall thus be handled with care.

3.5.1 Lifting rig

See Fig. 4. The diverter switch can be lifted out of the housing by means of a telpher. As a holder for the telpher, it is recommended to use rig LL117016-C. It can be ordered from the supplier. Install the supports on the flange of the top-section after the cover is removed.

**WARNING**

Make sure the rig is properly fixed to the cover flange before the diverter switch is lifted.

![Fig. 4. Lifting arrangement and lifting rig.](image-url)
3.6 Cleaning

3.6.1 Cleaning the diverter switch housing
Clean the inside of the housing by flushing with clean oil. Drain the oil.

**WARNING**
In no case should any person go down into the diverter switch housing. The cleaning of the diverter switch housing should be carried out by flushing with clean oil.

Drain the housing completely by using a hose before oil filling is carried out.

3.7 Oil filtration
To ensure oil quality until next overhaul, the drained oil shall be filtered or replaced with new inhibited oil (Oil I -30 °C according to IEC 60296). The drained oil should be filtered until it is cleaned and has regained the high dielectric strength required. The new or filtered oil shall comply with IEC 60422. The break-down value for purified oil should be at least 40 kV/2.5 mm according to IEC 60156.

To check the result of the filtering, take a test sample after the oil has been filled into the on-load tap-changer.

3.8 Checking of the breathing device
Check the breathing device according to the instructions from the transformer manufacturer.

**WARNING**
The breathers and the tube from the conservator might contain explosive gases. No open fire, hot surfaces or sparks may be present when loosening the breather.
3.9 Checking wear of the vacuum interrupters

The breaking occurs inside of the vacuum interrupters and thus the “avbränningen” of the contacts must be checked. Check by measuring with a thickness gauge between the set nut and the plastic yoke. See Fig. 5. The vacuum interrupters shall be replaced when the distance is min. 1 mm. The vacuum interrupters shall also be replaced if the calculated “avbränning” reduces distance to less than 0.5 mm until the next overhaul. The distance in new bottles is 3 mm and 0.5 mm for completely worn out bottles. Measure the distance and note the value for all 6 vacuum interrupters. This will make it possible to follow the “avbränningen” and compare the value at the next overhaul.

For replacement of the vacuum interrupters, please contact ABB.

CAUTION

The distance shall be measured without the thickness gauge pressing the set nut upwards, since the nut is spring loaded.

The set nuts are adjusted at delivery and must not be loosened or adjusted.

Fig. 5. Checking the contact wear.
3.10 Checking the transition resistors

The easiest way to check the transition resistor is to measure the resistance in the middle of the resistor module.

The measured resistance for N and B-2 phase unit shall be $\frac{1}{4}$ of the resistance value on the rating plate.

For E and T with a current of over 500 A, the value shall be $\frac{1}{4}$ of the value on the rating plate.

For B phase unit and E and T with a current below or equal to 500 A, see Appendix 2 for the measurement.

The value must not differ by more than 10%.
Check that the resistors are undamaged and that nothing has worked loose.

Fig. 6. The measurement point may be on the front side or backside of the stack.

3.11 Checking the contact timing

It is recommended to make a contact timing diagram when shafts, gears, motor-drive mechanism, tap selector and connections have been dismounted. Checking the contact timing is a good check of the condition of the on-load tap-changer, but it is not necessary to check contact timing at every overhaul. For more information, see Appendix 1.
3.12 Installation of the diverter switch

Remount the dehydrating breather.

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**CAUTION**

*Check the serial numbers to make sure that the diverter switch is mounted in the correct housing, see Fig. 2.*

*Make sure that the diverter switch housing is clean and dry and that no foreign objects (tools etc.) are left in the housing.*

*Lower the diverter switch into its housing carefully so that neither the diverter switch nor the housing are damaged.*

---

**WARNING**

*The vacuum interrupters are sensitive devices and the diverter switch shall thus be handled with care.*

The VUCG diverter switch is provided with two guiding slots: one that fits against the oil draining tube in the diverter switch housing and the other against the guiding bar, see Figs. 7 and 8.

When the diverter switch is lowered, check visually that its plug-in contacts are aligned with the contacts in the cylinder.

In order to ensure that the diverter switch pin has engaged the coupling disc, carry out at least three tap change operations in one direction. A distinct sound is heard when the diverter switch operates which indicates that the driving pin of the diverter switch has been connected.

If no sound is heard, the reason can be that the pin fits directly into the slot or that the diverter switch might need to be pushed down while operating the motor-drive.

Carry out another three operations in the same direction while pushing the diverter switch down.

The top part of the diverter switch lifting device should be below the level of the machined surface for the cover when lowered to its final position. Only the springs of the lifting device should be above this level.

If a check of the contact timing should be carried out, proceed with that according to Appendix 1 before mounting the cover.

Place a new O-ring for the cover in the upper flange. Mount the on-load tap-changer cover. Turn the cover so the guiding pin in the housing is facing the guiding hole in the cover. (The cover has to be pressed down in order to overcome the spring force of the springs which hold the diverter switch pressed in place.) Insert screws and washers and tighten them.
Fig. 7. Diverter switch

Fig. 8. VUCG Diverter switch housing, view from above
3.13 Checking the supervisory equipment

Accessories and safety devices that are not standard, but might be mounted at delivery, are described in a separate document: 1ZSC000562-AAD.

3.13.1 Functional check of the pressure relay

1. Set the valve handle to the test position as shown on the information plate.
2. Connect the air pump and the pressure gauge to the test tap on the pressure relay. (Thread R 1/8”).
3. Raise the pressure until the pressure relay trips the circuit breakers of the transformer.
4. Read the pressure on the manometer and check against the pressure stated on the information plate. Max. permitted deviation is ±10 %. If the deviation is greater, the pressure relay should be replaced.
5. Check that the signal disappears when the pressure is released.
6. After finishing the check, turn back the valve handle to service position.

3.12.2 Replacing the pressure relay

If replacement of the pressure relay is necessary, it is carried out according to the instruction in Repair Guide 1ZSE 5492-129.
3.14 Lubrication of the on-load tap-changer and the drive shaft system

The bevel gears are greased at delivery and the same type of grease is used for the couplings of the outer shaft system.

For access to the couplings, loosen the hose-clips and push the protective tubes together.
For access to the bevel gears, dismount the covers.

**WARNING**

The bevel gear contains moving gears. Be cautious!

Rotating shafts. Be cautious!

Check and lubricate with grease if necessary. Recommended types of grease are GULF-718 EP Synthetic Grease, Mobilgrease 28, Shell-Aero Shell Grease 22 or similar.

Remount covers (make sure the gaskets are properly in place).

3.15 Oil filling

If a check of the contact timing is to be carried out, see Appendix 1, fill the diverter switch housing with oil up to the transition resistors by the easiest possible method before checking. Oil fill completely according to the instructions below after checking the contact timing.

3.15.1 Filling methods and restrictions

After maintenance oil is normally filled at atmospheric pressure. This procedure is described in section 3.15.3. If filling is to be carried out under vacuum, see Installation and Commissioning Guide 1ZSE 5492-116.

**NOTE:** If new, degassed oil is filled into the diverter switch housing, gas may be dissolved in the oil. The oil level in the oil conservator may therefore decrease (be lower) and this is considered normal.
3.15.3 Filling at atmospheric pressure

**NOTE:** When filling more than one unit, fill all according to point 3 to 5.

1. Open the conservator valve, if any.
2. Dismantle the breathing device on the conservator for the on-load tap-changer.
3. Remove the cover.
4. Pump oil into the diverter switch housing via the oil valve (connection dimensions, see the dimension drawing for the on-load tap-changer). Continue until the housing is almost filled up (leave max. 10 mm to the cover flange).
5. Remount the cover as per section 3.12.
6. Continue to pump in oil until the conservator is filled to its correct level.
7. Shut the oil valve and disconnect the pump.
8. Remount the breathing device. Make sure the connection to the breathing device is properly sealed.

3.15.4 Waiting period

**CAUTION**

Do not energize the transformer earlier than three hours after oil filling in atmospheric pressure. This waiting period is needed to allow air bubbles to disappear.

3.16 Putting into operation

Operate the on-load tap-changer to the position noted in section 3.3.1. Put the LOCAL/REMOTE switch to REMOTE. Reset the drag hands. Make sure that no tools or foreign objects are left in the motor-drive mechanism cabinet. Close the door. Make sure that nothing is left on the transformer cover.

Sign the revision protocol and give it to the engineer in charge and inform that the on-load tap-changer is ready for energizing.

4. Replacement of vacuum interrupters

For replacement of the vacuum interrupters, please contact ABB. The interrupters are sensitive and the settings must be exact. It is thus important that the replacement is performed by a specialist.
5. 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.

5.1 General
On disposal of this product, it is recommended that local environmental regulations in each country are met. For environmental reasons, materials used are specified.

5.2 Diverter switch housing

<table>
<thead>
<tr>
<th>Material</th>
<th>Approx. amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>15 kg</td>
</tr>
<tr>
<td>Aluminium</td>
<td>75 kg</td>
</tr>
<tr>
<td>Copper and alloys</td>
<td>5 kg</td>
</tr>
<tr>
<td>Epoxy resin</td>
<td>35 kg</td>
</tr>
<tr>
<td>Transformer oil</td>
<td>150–200 kg</td>
</tr>
</tbody>
</table>

5.3 Diverter switch

<table>
<thead>
<tr>
<th>Material</th>
<th>Approx. amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>13 kg</td>
</tr>
<tr>
<td>Steel</td>
<td>27 kg</td>
</tr>
<tr>
<td>Copper and alloys</td>
<td>32 kg</td>
</tr>
<tr>
<td>Polyester resin with glass</td>
<td>7 kg</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>6 g</td>
</tr>
<tr>
<td>Silver</td>
<td>100 g</td>
</tr>
<tr>
<td>Chrome</td>
<td>100 g</td>
</tr>
<tr>
<td>Resistor wire (mainly copper and nickel alloys with small amounts of aluminium, magnesium and chrome)</td>
<td>4-45 kg</td>
</tr>
</tbody>
</table>

5.4 Tap selectors

<table>
<thead>
<tr>
<th>Tap selector I:</th>
<th>Approx. amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>50 kg</td>
</tr>
<tr>
<td>Copper and alloys</td>
<td>25 kg</td>
</tr>
<tr>
<td>Silver</td>
<td>0–100 g</td>
</tr>
<tr>
<td>Phenol resin laminate</td>
<td>20 kg</td>
</tr>
<tr>
<td>Polyester resin</td>
<td>5 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tap selector C:</th>
<th>Approx. amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>5 kg</td>
</tr>
<tr>
<td>Aluminium</td>
<td>15 kg</td>
</tr>
<tr>
<td>Copper and alloys</td>
<td>20 kg</td>
</tr>
<tr>
<td>Silver</td>
<td>70 g</td>
</tr>
<tr>
<td>Polyester resin</td>
<td>5 kg</td>
</tr>
<tr>
<td>Epoxy resin</td>
<td>15 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tap selector III:</th>
<th>Approx. amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>10 kg</td>
</tr>
<tr>
<td>Aluminium</td>
<td>40 kg</td>
</tr>
</tbody>
</table>
### Tap selector III:

<table>
<thead>
<tr>
<th>Material</th>
<th>Approx. amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper and alloys</td>
<td>50 kg</td>
</tr>
<tr>
<td>Silver</td>
<td>10 g</td>
</tr>
<tr>
<td>Polyester resin</td>
<td>10 kg</td>
</tr>
<tr>
<td>Epoxy resin</td>
<td>20 kg</td>
</tr>
</tbody>
</table>

### 5.5 Conductors

<table>
<thead>
<tr>
<th>Material</th>
<th>Approx. amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>5–10 kg</td>
</tr>
<tr>
<td>Cellulose</td>
<td></td>
</tr>
</tbody>
</table>

### 5.6 Gearing mechanism

<table>
<thead>
<tr>
<th>Material</th>
<th>Approx. amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>15 kg</td>
</tr>
<tr>
<td>Copper and alloys</td>
<td>5 kg</td>
</tr>
</tbody>
</table>

### 5.7 Drive shaft systems

<table>
<thead>
<tr>
<th>Material</th>
<th>Approx. amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>8 kg</td>
</tr>
<tr>
<td>Aluminium</td>
<td>2 kg</td>
</tr>
<tr>
<td>Brass</td>
<td>2 kg</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>2 kg</td>
</tr>
</tbody>
</table>
Appendix 1

Checking the contact timing

The test requires:

- Two indicator lamps (glow discharge lamps for the minimum possible magnetisation of the transformer)
- Necessary leads
- Two stiff insulated leads or bars

**WARNING**

Never force DC current through the transformer windings.

The insulated leads (or bars) are used for connection to the moving contact arms of the tap selector via the plug-in contacts of the diverter switch. (They can be made of an insulating tube with a lead inside.)

Connect the lamps as shown in Fig. 11.

The diverter switch contacts are designated as shown in Fig. 12. Determine if x or v contacts are closed. In the contact-timing diagram for the on-load tap-changer you can find out the corresponding position. See Figs. 15 and 16.

At repeated operations in the same direction the selector arms V and H operate every second time. When the direction of operation is reversed, the contact arms will be at rest during the first operation. The operation is then performed by means of the diverter switch only.

**NOTE:** When testing, the operation must be carried out in the same direction as the previous operation.

---

*Fig. 11. Indicator lamp connection during contact timing test.*

*Fig. 12. The diverter switch outlet marking.*
The test is to be made on all three-phases and is to be carried out as follows:

Find the exact position of the on-load tap-changer by adjusting the disc brake as shown in Figs. 13 and 14.

1. Note the number of whole turns and parts of turns on the hand crank, during a slow manual operation.
2. Note when each tap-selector arm breaks and makes (the corresponding lamp goes out or lights).
3. Note when the diverter switch flicks over (a distinct sound is heard).

After this, compare the operations with the contact-timing diagram applicable to the on-load tap-changer in Figs. 15 and 16.

One operation corresponds to 25 turns of the hand crank on the motor-drive mechanism, type BUE and 15 turns for BUL.

Remove the equipment for contact-time measuring.

Complete the oil filling according to section 3.14.

**CAUTION**

*If the result is beyond the limits given here, please contact ABB.*
NOTE: The diverter switch must have switched over before the 22.5th turn is finished with the hand crank.

Fig. 15. Example of contact-timing diagram, BUE

NOTE: The diverter switch must have switched over before the 13.5th turn is finished with the hand crank.

Fig. 16. Example of contact timing diagram, BUL

NOTE: The diverter switch must have switched over before the 13.5th turn is finished with the hand crank.
Appendix 2

Checking the transition resistors

The measured resistance for E, T and YD units shall be ¼ of the value at the rating plate. For all B one-phase units the resistance shall be ¼ of the value at the rating plate.

Table 3.

<table>
<thead>
<tr>
<th>Type</th>
<th>Current</th>
<th>Step voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>E, T, YD</td>
<td>0-500 A</td>
<td>-</td>
</tr>
<tr>
<td>B one-phase</td>
<td>401-600 A</td>
<td>0-1000 V</td>
</tr>
<tr>
<td>B one-phase</td>
<td>0-400 A</td>
<td>1001-3500 V</td>
</tr>
<tr>
<td>B one-phase</td>
<td>534-600 A</td>
<td>1001-1400 V</td>
</tr>
</tbody>
</table>

Table 4.

<table>
<thead>
<tr>
<th>Type</th>
<th>Current</th>
<th>Step voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B one-phase</td>
<td>401-533 A</td>
<td>1001-2625 V</td>
</tr>
<tr>
<td>B one-phase</td>
<td>451-494 A</td>
<td>2626-3500 V</td>
</tr>
<tr>
<td>B one-phase</td>
<td>495-533 A</td>
<td>2626-3196 V</td>
</tr>
</tbody>
</table>
### Table 5.

<table>
<thead>
<tr>
<th>Type</th>
<th>Current</th>
<th>Step voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B one-phase</td>
<td>601-713 A</td>
<td>0-1000 V</td>
</tr>
</tbody>
</table>

### Table 6.

<table>
<thead>
<tr>
<th>Type</th>
<th>Current</th>
<th>Step voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B one-phase</td>
<td>601-713 A</td>
<td>1001-2653 V</td>
</tr>
<tr>
<td>B one-phase</td>
<td>401-450 A</td>
<td>2626-3500 V</td>
</tr>
</tbody>
</table>
### Table 7.

<table>
<thead>
<tr>
<th>Type</th>
<th>Current</th>
<th>Step voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B one-phase</td>
<td>0-400 A</td>
<td>0-1000 V</td>
</tr>
</tbody>
</table>

### Table 8.

<table>
<thead>
<tr>
<th>Type</th>
<th>Current</th>
<th>Step voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B one-phase</td>
<td>534-600 A</td>
<td>2207-2942 V</td>
</tr>
</tbody>
</table>

### Table 9

<table>
<thead>
<tr>
<th>Type</th>
<th>Current</th>
<th>Step voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B one-phase</td>
<td>534-600 A</td>
<td>1401-2206 V</td>
</tr>
</tbody>
</table>