On-load tap-changers, type UBB
Installation and commissioning guide
Original instruction

The information provided in this document is intended to be general and does not cover all possible applications. Any specific application not covered should be referred directly to ABB, or its authorized representative.

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**Recommended practices**

ABB recommends careful consideration of the following factors when installing on-load tap-changers:

Before you install or commission a unit, make sure that the personnel doing the job have read and fully understood the installation and commissioning guide 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.

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

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**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.

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**CAUTION**

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

CAUTION may also indicate property-damage-only hazards.

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

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**Safety precautions**

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**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 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 and use oil-tight protective gloves when handling the oil.

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

Collect used oil in oil drums.

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

In the event of fire: Any fires should be extinguished with powder, foam or carbonic acid extinguishing agents.

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**WARNING**

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

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**WARNING**

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

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**WARNING**

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

Before carrying out work on the tap-changer, put the LOCAL/REMOTE switch on the motor-drive mechanism to position LOCAL or 0, and switch the protective motor device to 0. It is also advisable to shut the door of the motor-drive mechanism and padlock it when work is carried out on the tap-changer. The key should be kept by the operator. This is done to avoid an unexpected start of the motor-drive mechanism.

WARNING

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

NOTE: The motor, contactors and heating element may be energized from separate sources.

During drying of the transformer

CAUTION

While drying with hot air and vacuum, the maximum permitted pressure difference for the tap-changer is 100 kPa at the maximum permitted temperature of 135 °C (275 °F).

CAUTION

During drying with the vapor phase process, the cover of the tap-changer and the bottom valve should be left open. The maximum permitted temperature is 135 °C (275 °F).

CAUTION

Use the special bottom valve key only (delivered with the tap-changer) to operate the bottom valve. The use of a stiffer tool may damage the valve.

CAUTION

To avoid seizing, do not operate the tap-changer during the drying process or afterwards until it is filled with oil.

Mounting of gaskets

CAUTION

Sealing surfaces and gaskets must be clean and undamaged. Diagonically 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 1.7 in this guide.

During oil filling

WARNING

When oil that has been used in a tap-changer is pumped out, grounded conducting tubes and hoses should be used to avoid the risk of explosion due to the gases produced by arcs during service.

CAUTION

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

CAUTION

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

CAUTION

Leave a gas cushion on top of the oil in the tap-changer.
After oil filling

**CAUTION**

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

Check the oil level one month after filling. It is usual for the oil level of the oil conservator to fall due to gas absorption in the oil from the gas cushion in the tap-changer, if the tap-changer is not operated. Restore the gas cushion and the oil level according to Section 7.5.

During service

**WARNING**

Small amounts of explosive gases may be emitted from the breathing devices (dehydrating breather or one-way breather). Make sure that no open fires, hot surfaces or sparks occur in the immediate vicinity of the breathing devices.

**WARNING**

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

**WARNING**

The hand crank must not be inserted during electrical operation.

**WARNING**

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.

**CAUTION**

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. Do not open the pressure relay package until just prior to installation on the tap-changer.
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1. Introduction

The delivery consists of on-load tap-changer, motor-drive mechanism and drive shaft system.

The tap-changer may be specified for cover-mounting or for yoke-mounting.

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

Yoke-mounting means that the tap-changer is temporarily put onto a fork located on the active part of the transformer. Yoke-mounting allows the transformer manufacturer to connect the windings to the tap-changer before drying and without having the transformer cover mounted. The transformer cover is then lowered onto the tank, and the tap-changer is lifted and bolted to the cover. Please use the appropriate instruction for cover-mounting or yoke-mounting!

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

The general arrangement of an tap-changer system is shown in Fig. 1.

The general arrangement of an tap-changer type UBB is shown in Fig. 2.

![Fig. 1. On-load tap-changer system.](image_url)
Fig. 2. General arrangement of on-load tap-changer, type UBB.
1.1 Required tools
- 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 19 mm)
- Standard set of sockets (up to 19 mm)
- Socket handle
- Socket extender
- Standard set of screw drivers
- Allen key sockets 5 and 6 mm
- Lifting bar LL 117 016-K (yoke-mounting only)
- Dynamometric wrenches, 5-85 Nm
- Bottom valve key (delivered with the tap-changer)
- Tool for opening of oil drum
- Hack saw
- Bucket, 10 liters
- Lifting jack

1.2 Required material
- Grease, (Ball bearing grease) GULF-718 EP, Mobil-Grease 28, SHELL-Aero Shell Grease 22 or similar
- Equipment for oil filling
- Sealing tape
- Rags (lint-free) for cleaning

1.3 Oil
The oil quality should be of Class II according to IEC 60296, 2012-02. The oil weight according to table 1 in section 1.6.

**WARNING**
Do not energize the transformer until oil has been filled according to chapter 6 in this guide.

1.4 Oil conservator
The tap-changer has to be connected to an oil conservator. ABB recommends the use of a separate conservator for the tap-changer with both oil and air side separated from the main conservator of the transformer.

The volume of the conservator should be such that there is oil left in the conservator even at the lowest oil temperature expected and such that no flooding can occur at the highest oil temperature expected. Even transformers with more than one tap-changer unit require only one conservator.

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

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

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

1.5 Oil filter unit for continuous oil filtration
If the tap-changer should have an oil filter unit for continuous oil filtration from ABB, installation and commissioning instructions can be found in the oil filter unit manual, delivered with the oil filter unit.

1.6 Weights
The approximate weight of the tap-changer is stated in Table 1. The motor-drive mechanism and the drive shaft system are not included in the overall weight.

<table>
<thead>
<tr>
<th>Type designation</th>
<th>Dimension H mm</th>
<th>Approx. weight in kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Tap-changer without oil</td>
</tr>
<tr>
<td>UBBLN XXX/YYY</td>
<td>1193</td>
<td>140</td>
</tr>
<tr>
<td>UBRN XXX/YYY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBBDN XXX/YYY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBBLT XXX/YYY</td>
<td>1489</td>
<td>155</td>
</tr>
<tr>
<td>UBBRT XXX/YYY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBBDT XXX/YYY</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Motor-drive mechanism (BUL2): 95 kg
Motor-drive mechanism (BUE): 130 kg
Drive shaft system: Approx. 10 kg

1.7 Tightening torque
The following tightening torques are recommended:

For metallic bolt joints: M6 ........... 10 Nm ±10 %
M8 ........... 24.5 Nm ±10 %
M10......... 49 Nm ±10 %
M12........... 84 Nm ±10 %

if not otherwise stated in this guide.
2. Receiving

2.1 Unpacking
Check that the packages are free from transport damage. Open the covers of the transport boxes. Remove the supporting blocks of wood. If the package is damaged a careful investigation must be carried out.

Lift the tap-changer, using the lifting eyes on the top.

2.2 Inspection upon receiving
1. Check that the tap-changer, drive shaft system, motor-drive mechanism and accessories are undamaged.
2. If transport damage is found, and it is judged that correct operation of the tap-changer is not possible, a damage report should be sent to the insurance company. It is also recommended that photos are taken of the damaged details. Mark the photos with ABB's reference number and the serial number of the tap-changer and send them to ABB for comments.
3. Check that the parts delivered, type designations and the serial number agree with the delivery documents, e.g. the packing list or ABB’s ordering acknowledgement. The serial number is stamped on the rating plate and on the tap-changer flange. The serial number on the parts belonging to one tap-changer unit should all be the same.

2.3 Temporary storage before assembly
If the tap-changer is not to be assembled immediately, once the delivery has been approved the tap-changer and the motor-drive mechanism must be kept warm and dry indoors. Let the units be kept in their plastic enclosures and leave the drying agent until assembly.
The cover-mounting method (chapter 3.1) or yoke-mounting method (chapter 3.2) is used.

When lifting an UBB model it is recommended to use the lifting eyes on the tap-changer top section.

WARNING

Lowering the complete tap-changer to the floor without support entails a risk for tipping, personal injury and equipment damage.

3.1 Cover-mounting

1. Place the gasket (O-ring or plane gasket is usable) around the opening in the transformer cover. (This gasket is not included in the tap-changer delivery).
2. Check that the tap-changer flange is positioned in the right way in rotational relation to the transformer cover.
3. Lower carefully without damaging the terminals the whole tap-changer through the hole in the transformer cover. If the tap-changer is equipped with tie-in resistors mounted on the outside terminals, they have to be removed during lowering the tap-changer through hole in the transformer cover. The studs on the transformer cover shall fit into the holes in the flange of the tap-changer. Fit washers and nuts. Tighten.

Fig. 3. Cover-mounting details.
3.1.1 Connection to outside terminals
The connection to terminals for change-over selector, selector switch and current collector shall follow the connection diagram delivered with the tap-changer. Connection holes for bolts M10 are Ø11 mm for all terminals.

⚠️ CAUTION
All connections shall be made carefully and in such a way that there is no risk for them to come loose. Furthermore, the conductors must not cause mechanical stresses on the outside terminals. Make an expansion bend on every conductor. See Fig. 4.

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

⚠️ CAUTION
The transformer designer is responsible for providing sufficient insulating distances in the oil.

ℹ️ There is no need of outer neutral connection leads at UBB.N-types, because there is already a built-in connection in the tap-changer insert.

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Fig. 4. Connection to outside terminals.
3.2 Yoke-mounting
(Pre-mounting on active part of the transformer).

The top section of the tap-changer is designed to be divided into an upper and a lower flange, see Fig. 5, to fit the yoke-mounting.

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

![Diagram of yoke-mounting](image)

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

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

Transformer ratio measurement before drying, see section 3.2.1.

Transformer ratio measurement after drying, see section 3.2.2.

Mounting onto the transformer cover from the yoke, see section 3.2.3.
3.2.1 Mounting of the tap-changer when transformer ratio measurement is carried out before drying

Mounting to the yoke-fork of the transformer, see Fig. 7.

1. Mount the tap-changer on the transformer’s yoke-fork, the lifting lugs on the upper part can be used. Handle with care without damaging the terminals and tie-in resistors (if any).

   Check that the tap-changer is positioned in the right way in rotational relation to the transformer cover, before connection of conductors.

2. Connect the conductors according to section 3.1.1.
3. Transformer ratio measurement.
4. The tap-changer can be operated by turning the shaft of the bevel gear. Use a special hand crank, LL 117 016-M.
5. Two turns in clockwise direction (seen against the shaft end) for RAISE or two turns counterclockwise for LOWER operation, will be equal to one switching between two taps. Check the order documents if otherwise is stated according to the direction of rotation.

   CAUTION
   The tap-changer should be operated through the whole operating range, both in lower and raise direction, when carrying out ratio measurement.

   CAUTION
   The end positions must not be overrun during ratio measurement. When operating the tap-changer without drive system, check the designation of the end positions on the single-phase diagram and watch the position indicator in the bevel gear in order to avoid overrunning of the end position.

6. After the measurement, the position of the tap-changer must be replaced to the same position as the motor-drive mechanism indicates, check in the indicator window on the top cover.
7. Loosen all the twelve bolts and washers in the top cover and lift the cover carefully min. 10 cm straight upwards before moving it in horizontal direction. The bevel gear and the pipe may not be damaged when lifting. If a crane is used arrange the straps according to Fig. 7.
8. Remove the upper part of the top-section by loosening the twelve M8-socket head cap screws inside it. Keep the flange, the cover, the O-rings and the sealing for the suction pipe, see Figs. 5 and 9 and store them temporarily on a dustfree place.
9. The tap-changer and the transformer is now ready for drying. Follow the instructions in chapter 5.

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

   Spacers (for example of wood) can be placed between the yoke-fork and the lower flange. The connectors can hereby be mounted on the right final height. The spacers must be removed before mounting of the tap-changer onto the transformer cover. See Fig. 6.

   CAUTION
   Watch the voltmeter during the tap-changer operations. No fast voltage drops may occur during operation. If such drops occur, the tap-changer is not correctly connected to the winding.

Fig. 6.
Fig. 7.

Fig. 8.

Fig. 9.
3.2.2 Mounting of the tap-changer when transformer ratio measurement is carried out after drying
Mounting to the yoke-fork of the transformer. See Fig. 10.

1. Loosen all the twelve bolts and washers in the top cover and lift the cover carefully min. 100 mm straight upwards before moving it in horizontal direction. The bevel gear and the pipe may not be damaged when lifting. If a crane is used arrange the straps according to Fig. 7.

2. Remove the upper part of the top section by loosening the twelve M8-socket head cap screws inside it. Keep the flange, the cover, the O-rings and the sealing for the suction pipe, see Fig. 5 and store them temporarily on a dustfree place.

3. When lifting the tap-changer onto the yoke-fork it is recommended that lifting eyes M12 are mounted in the lower flange.

4. Remove the lifting eyes when the tap-changer is in right position on the yoke-fork.

5. The tap-changer and the transformer is now ready for drying. Follow the instructions in chapter 4.
3.2.3 Mounting to the transformer cover from the yoke (after the drying process)

1. Place the O-ring in its groove in the lower flange.

2. Place the gasket around the opening of the transformer cover. (This gasket is not included in the tap-changer delivery).

Do not mount the studs for the upper flange now, they will be mounted according to point 10.

3. Place the upper flange over the opening of the transformer cover. Check that the flange is positioned in the right way in rotational relation to the lower flange.

4. Mount the lifting bar on the upper flange with the four long bolts through the clearance holes in the upper flange and in the tapped holes in the lower flange, see Fig. 12.

The tap-changer is provided with a suction pipe, see Fig. 5, the sealing may not be damaged when mounting the lifting bar.

5. Couple a lifting block or crane to the lifting bar.

6. Check when lifting that the guiding pin in the lower flange clear the hole in the upper flange.

CAUTION
Lift very carefully to avoid damages onto the tap-changer.

7. Lift the tap-changer until it touches the upper flange. Mount a washer and a screw in each of the free holes.

8. If the holes in the upper flange do not match the holes in the transformer cover, the position of the tap-changer must be adjusted, which may require a careful lifting. Mount two studs (diametrical positions) in the transformer cover.

9. Remove the lifting bar and mount a washer and a screw in each of the free holes.

(An alternative method, if the lifting bar is not available, is to use 4 studbolts M8x70 for lifting the cylinder: Place the studs at opposite directions through the clearance holes in the upper flange and threaded into the lower flange. Mount washers and nuts on the studs. Then lift the cylinder by tightening of the nuts. Check when lifting that the guiding pin in the lower flange enters the hole in the upper flange. Mount screws and washers in each of the 8 free holes in the upper flange. Remove the lifting studs and mount screws and washers also in those holes.)

10. Mount the studs in the transformer cover through the holes in the upper flange. Fit washer and nuts.

11. Mount the O-ring in the groove in the upper flange and mount the sealing for the suction pipe, see Fig. 5.

12. Before mounting of the top cover check that the position of the driving disc, on the lower side of the cover, is according to Fig. 13.

CAUTION
Before mounting of the top cover make sure that no foreign objects are in the tap-changer.

13. Lower the top cover straight down against the upper flange, the guiding pin in the flange shall clear the hole in the lower side of the cover.

CAUTION
The position of the driving disc must be according to that in Fig. 12 and the guiding pin must clear the hole at mounting of the top cover.

14. Mount the washer and M12 bolts for the top cover.
Fig. 12. Mounting onto the transformer cover.
Fig. 13.
A drying agent is placed inside the package to keep the tap-changer dry during transport. It is not necessary to dry the tap-changer if the package not have been destroyed.

The tap-changer can be dried together with the transformer according to one of the following processes: alternating hot-air and vacuum or vapour-phase at a temperature of max. 135 °C (275 °F) and a maximum pressure difference of 100 kPa between tap-changer and transformer.

### 4.1 Observations before processing

1. When drying with the vapour-phase process the bottom valve of the tap-changer shall be open and the cover of the tap-changer, the O-ring and the sealing of the suction pipe shall be removed. See section 3.2.2, point 1. To open the bottom valve, proceed as follows: Use the delivered bottom valve key to engage the internal hexagon hole of the bottom valve. Open the valve by turning counterclockwise max. 4 turns.

2. When drying in a vacuum pan with the hot-air process, the top cover of the tap-changer, the O-ring and sealing of the suction pipe shall be removed. See section 3.2.2, point 1.

### 4.2 Observations after processing

**CAUTION**

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

1. Make sure that all liquid has been drained from the tap-changer. Close the bottom valve. Tightening torque is approximately 15 Nm.

2. If a tie-in resistor from ABB is supplied, its screw joints are to be retightened (tightening torque 15 Nm) and locked by the method specified by the transformer manufacturer.
5. Final assembly

5.1 Mounting of the motor-drive mechanism
See Figs. 1, 14 and 15.

Proceed as follows:

1. Mount the motor-drive mechanism onto the transformer.

   The mounting holes on the transformer should be leveled within 1 mm. If adjustment is needed, shims should be used.

2. Install the bevel gear on the edge of the transformer cover.

3. Check that the position indicator in the motor-drive mechanism shows the same position as the indicator inside the top cover of the tap-changer.

   **WARNING**

   Do not energize the transformer before the tap-changer and motor-drive mechanism are correctly assembled.
Fig. 14. Position alignment for type BUE.
Fig. 15. Position alignment for type BUL2.

Indicator window

Cam disc

Brake disc

Adjusting screw

Contra nut

Roller on brake arm in the notch of the cam disc

Position indication

White indicator flag

Brake arm

Cam disc

Brake disc

Adjusting screw
5.2 Mounting of accessories
The accessories on the tap-changer top cover can be rearranged to suite the individual transformer.

The bevel gear is turnable in order to have the horizontal shaft to the motor-drive mechanism in right direction. The limit for the turning depends on the arrangement of the accessories but is max. 140° respective 125° as in Fig. 16. The tube bends are turnable to suite for example the location of the conservator and the oil filter unit (if any). The flanges "A" are equal and their accessories can be changed between them.

We recommend that the air release valve to the transformer, see Fig. 2, is replaced by a pipe to the gas operated relay in order to get a signal from the relay as quick as possible in case of gas production in the transformer.

⚠️ CAUTION

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. Do not open the package of the pressure relay until you are about to install it on the tap-changer.

5.3 Mounting of external drive shafts
The external drive shafts consists of square tubes and shall be connected to the spherical shaft ends on bevel gears and motor-drive mechanism by means of two coupling halves. The square shafts and protective tubes must be cut before mounting.

⚠️ CAUTION

Before mounting of shafts and couplings, everything must be cleaned and greased for correct function and to avoid corrosion.

Apply a thin layer of grease, GULF-718EP Synthetic grease or Mobilgrease 28 or SHELL-Aero Shell Grease 22 to all spherical shaft ends and unpainted surfaces of the bevel gears.

⚠️ CAUTION

The motor-drive mechanism and tap-changer shall have the same indicated tap position. See section 5.1.

The inclination of the shaft (the square tube) must not be more than 4° (=70mm for every 1000 mm shaft length).

ℹ️ The tubes around shafts and couplings are for protection.

The arrangement of the driving shaft system is shown in Fig. 17.
Fig. 17. External shaft system.

1) Included in SA 26
5.3.1 Mounting of horizontal drive shaft

1. Mount the bevel gear SA21 on the transformer, with O-ring SA20, four clamps SA17, hexagon head bolts M10, SA18 and washers SA19, see Fig. 17.

2. Determine the dimension K1 between the spherical shaft ends, see Fig. 18.

3. Cut the square shaft SA22 to dimension = K1 minus 6 mm. Remove the burrs.

4. Cut the protective tubes SA23 and SA24 in the unslotted end so that both of them get the same length LB1 according to Table 2.

5. Fit two coupling halves, SA11, on one end of the square shaft with six screws SA12 and washers, SA13. Push the shaft to the bottom of the fitting in the coupling halves. Tighten the two screws first and then the others, see Fig. 20. Put on the two protective tubes, SA23 and SA24, the slotted ends outwards, and two hose clips SA10, see Fig. 19.

6. Connect the square shaft with the mounted coupling halves to the shaft of the bevel gear SA21, see Fig. 23. Mount two coupling halves SA11 to the square shaft perpendicular to the coupling in the other end and to the shaft of the bevel gear on the tap-changer. Tighten light the screws and check that the shaft not can be moved more than 2 mm in axial direction (axial play). Tighten the two screws first and thereafter the other, see Figs. 20 and 21. If necessary the axial play may be adjusted by moving the couplings on the shaft end according to Fig. 22.

7. Push the two protective tubes on to the bevel gears and clamp them with hose clips, SA10, see Fig. 24.

The slot of the protective tubes SA23 and SA24 shall be facing downwards.

Apply the self-adhesive information plates SA25 around the tubes on about the middle of the tube length.

Table 2. Length dimension for LB1.

<table>
<thead>
<tr>
<th>K1</th>
<th>LB1</th>
</tr>
</thead>
<tbody>
<tr>
<td>190 to 290 mm</td>
<td>K1 + 180 mm</td>
</tr>
<tr>
<td>291 to 600 mm</td>
<td>K1 + 210 mm</td>
</tr>
<tr>
<td>greater than 600 mm</td>
<td>K1 + 410 mm</td>
</tr>
</tbody>
</table>

Example:

K1 measured to 390 mm. LB1 is then = 390 + 210 = 600 = 300 mm

If K1 is greater than 600 mm the mounted tubes shall overlap each other at least 300 mm. Dismounting and inspection of the couplings shall be possible when one of the tubes is pushed into the other.
Fig. 20.

Fig. 21.

Fig. 22.

Fig. 23.

Fig. 24.
5.3.2 Mounting of vertical drive shaft

1. Determine the dimension $K_2$ between the spherical shaft ends, see Fig. 25.

2. Cut the vertical square shaft, $SA_{14}$, to dimension $= K_2$ minus 6 mm. Remove the burrs.

3. Cut the protective tubes $SA_{15}$ and $SA_{16}$ so both of them get the same length $LB_2$ according to the table 3 below.

4. Fit two coupling halves, $SA_{11}$, on one end of the square shaft with six screws $SA_{12}$ and washers $SA_{13}$. Push the shaft to the bottom of the fitting in the coupling halves. Tighten the two screws A first and then the other. See Fig. 20. Put on the two protective tubes, $SA_{15}$ and $SA_{16}$, and two hose clips $SA_{10}$. See Fig. 25.

5. For $BUE$ motor-drive mechanism loosen the two screws in the multiple hole coupling inside the motor-drive mechanism. See Fig. 26. For $BUL2$ motor-drive mechanism place the multiple hole coupling half ($SA_{26}$) on the coupling half on the outgoing shaft. See Fig. 26.

6. Connect the square shaft with the mounted coupling halves to the shaft of the bevel gear. Mount two coupling halves $SA_{14}$ to the square shaft perpendicular to the coupling in the other end, and the shaft of the motor-drive mechanism. Tighten the screws lightly and check that the shaft not can be moved more than 2 mm in axial direction (axial play). Tighten the screws A first and thereafter the other. See Fig. 20 and Fig. 27.

7. Mount the tube with the greater diameter, $SA_{16}$, to the bevel gear with a hose clip $SA_{10}$. See Fig. 27.

8. Check that the motor-drive mechanism is in the EXACT position and that the position indicator in the motor-drive mechanism shows the same position as the indicator inside the top-cover of the tap-changer. 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. 14. EXACT position for the $BUL2$ is when the roller on the brake arm is in the notch of the cam disc. See Fig. 15. If out of position hand crank the motor drive mechanism to EXACT position according to above.

9. Open the cover of the gear box on the top cover of the tap-changer. Check that the key on the vertical shaft in the bevel gear is facing the earthing symbol on the flange of the tap-changer. See Fig. 28. If not, the multiple hole coupling must be adjusted. Turn the vertical shaft until the

---

Table 3. Length dimensions for $LB_2$.

<table>
<thead>
<tr>
<th>$K_2$</th>
<th>$LB_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$200$ to $290$ mm</td>
<td>$LB_2 = K_2 + 180$ mm</td>
</tr>
<tr>
<td>$291$ to $600$ mm</td>
<td>$LB_2 = K_2 + 210$ mm</td>
</tr>
<tr>
<td>Greater than $600$ mm</td>
<td>$LB_2 = K_2 + 410$ mm</td>
</tr>
</tbody>
</table>

---

Fig. 25.

Fig. 26.
key is facing the earthing symbol. Mount the two screws and the locking nuts in the two holes of the coupling halves which are closest to each other and tighten.

**WARNING**

The bevel gear contains moving gears. Be cautious!

**CAUTION**

If the key is not in position as described above, the tap-changer operation will be too early in one direction and too late in the opposite direction.

**CAUTION**

The motor-drive mechanism and the tap-changer shall have the same indicated tap position and the key in the bevel gear onto the tap-changer shall be facing the earthing symbol according to Fig. 28.

10. Pull down the protective tube SA15 and mount the hose clip SA10. See Fig. 29. Note the clearance for draining. (Min 3 mm, max 5 mm).

11. Remount the cover of the gear box on the top of the tap-changer.
5.4 Connection to the oil conservator

If oil filling is done under vacuum without oil conservator, this section is carried out after oil filling. See Fig. 30.

Remove the transport cover on the tube bend. Make sure the O-ring is in place and connect the pipe to the oil conservator. Tighten the nuts.

**CAUTION**

In case where the conservator is common for the transformer and the tap-changer, an oil filter must be placed in the pipe between the tap-changer and the conservator.

Oil filter with housing can be ordered from ABB.

5.5 Before operation

1. Check that the tap-changer and the motor-drive mechanism have the same indicated position and that the key position of the tap-changer bevel gear is in accordance to Fig. 28.
2. Remove the locking device of the motor-drive mechanism (if not already done). See Fig. 31.
5.5.1 Transformer ratio measurement after drying
If transformer ratio measurement is to be done after drying this is a suitable stage to carry it out.

⚠️ CAUTION ⚠️

To avoid seizing, do not operate the tap-changer until it is filled with oil.

Carry out this measurement after the drive system is mounted. Operate the tap-changer by means of the motor-drive mechanism.

⚠️ CAUTION ⚠️

The tap-changer should be operated through the whole operating range, both in lower and raise direction, when carrying out ratio measurement.

⚠️ CAUTION ⚠️

The end positions must not be overrun during ratio measurement. When operating the tap-changer without drive system, check the designation of the end positions on the single-phase diagram and watch the position indicator in the bevel gear in order to avoid overrunning of the end position.

⚠️ CAUTION ⚠️

Watch the voltmeter during the tap-changer operations. No fast voltage drops may occur during operation. If such drops occur, the tap-changer is not correctly connected to the winding.

5.6 Supervisory equipment
Accessories and safety devices are described in a separate document, Accessories and protection devices for on-load tap-changers, 1ZSC000562-AAD.
6. Oil filling

6.1 Filling methods and restrictions
Oil filling can be carried out at atmospheric pressure or under vacuum. The wall between the tap-changer and the transformer tank is designed to withstand vacuum on one side and atmospheric pressure on the other side. It is not allowed to have vacuum on one side and the pressure of an oil column on the other side.

Oil filling may be carried out in different ways depending on what the transformer manufacturer finds convenient as long as the rules above are fulfilled and the tap-changer is filled with oil to the correct level.

The methods below are recommended and if they are followed in detail no pressure limits are exceeded and oil levels and gas cushions will be correct.

After oil filling, a gas cushion should remain on the top of the oil in the selector switch housing.

The connection to the oil conservator is designed to automatically give a gas cushion when filling at atmospheric pressure. When filling under vacuum a certain amount of oil has to be drained in order to obtain the gas cushion. See section 7.5.

The oil dissolves gases, especially if degassed oil is used. If the number of operations is low, the gas cushion may be dissolved in the oil.

If the transformer is filled at atmospheric pressure the air release valve on the flange should be opened and the trapped air let out. Even better is to replace the air release valve with a pipe to the gas operated relay.

6.2 Filling at atmospheric pressure

1. Open the conservator valve, if any.
2. Dismantle the pipe to the breather. Or, if simpler, take away the dehydrating breather.
3. Connect the pump to the oil valve on the tap-changer cover. Open the valve and pump in oil to the correct level shown on the oil level indicator. For correct oil level, see section 7.4.
4. Shut the oil valve and disconnect the pump.
5. Reassemble the pipe or the breather. The connections must be airtight, use sealing tape on the threads and O-rings in the flanges.

When the transformer and the tap-changer have a common oil conservator, a filter in the connection between the tap-changer and the conservator is needed.

1. The conservator valve should be shut.
2. Open the air release valve on the oil filter housing.
3. Connect the pump to the oil valve on the tap-changer cover. Open the valve and pump in oil. Stop the pump when oil reaches the air release valve.
4. Shut the oil valve and the air release valve and disconnect the pump.
5. Open the conservator valve.

An appropriate gas cushion automatically remains under the top cover by those methods.

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.

6.3 Filling under vacuum
Oil filling under vacuum is not necessary. If it is to be carried out, the tap-changer and the transformer tank should be put under vacuum simultaneously.

It is assumed that a vacuum-proof conservator is in use.

1. Open the conservator valve, if any.
2. Dismantle the pipe to the breather, or, if simpler, remove the dehydrating breather.
3. Connect the transformer to the breather connection on the conservator for the tap-changer.
4. Apply vacuum.
5. Connect the oil filling equipment to the oil valve on the tap-changer. Open the valve and let oil into the tap-changer until the correct level is shown on the oil level indicator. For correct oil level see section 7.4.
6. Shut the oil valve and disconnect the filling equipment.
7. When filling of the transformer is completed disconnect the vacuum pump and let air into the conservator.
8. Reassemble the pipe or the breather. The connections must be airtight; therefore use sealing tape on the threads and O-rings in the flanges.
6.4 Correct oil level
For installations where the tap-changer and the transformer tank have a common oil conservator, the instructions for the transformer should be used.

If possible, the oil levels of the oil conservators of the transformer tank and the tap-changer should be the same. The oil level of the oil conservator of the tap-changer should in no case be higher than the oil level of the transformer oil conservator.

At +20 °C (68 °F), oil is filled to the level where the pointer of the oil level indicator points half-way between MIN and MAX.

For other temperatures than +20 °C (68 °F), proceed as follows:
- For every 10 °C (18 °F) increase of temperature, adjust the oil level upwards a tenth of the scale range of the oil level indicator.
- For every 10 °C (18 °F) decrease of temperature, adjust the oil level downwards a tenth of the scale range of the oil level indicator.

6.5 Restoring the gas cushion

**WARNING**
Before any work is carried out on the 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.

After oil filling under vaccum a gas cushion has to be formed. Proceed as follows:
1. Shut the conservator valve.
2. Connect a pump to the oil valve and start to suck out oil. Open the air vent to the tap-changer and let air in. Stop the pumping after about 2 liters of oil has been sucked out from the tap-changer.

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

3. Shut the air vent and the oil valve and disconnect the pump.
4. Open the conservator valve and an appropriate gas cushion will be formed.

If the tap-changer has been filled with degassed oil and has a very low frequency of operation, the gas cushion may have been absorbed by the oil. To avoid fault trip by the pressure relay, the gas cushion should be restored as above.

**CAUTION**
To operate the tap-changer with a too small or no gas cushion means a risk for a trip of the pressure relay.

The procedure above is used for tap-changers without oil filter unit for continuous oil filtration. In case the tap-changer is equipped with an oil filter unit for continuous oil filtration from ABB, and it is installed according to our recommendations, follow the instructions in "Oil filter unit for tap-changers, manual" for restoring the gas cushion.

**CAUTION**
Avoid to do the restoring in damp weather since moisture will get into the selector switch housing. If the restoring has to be done in such weather, the incoming air has to be dehydrated.
7. Electrical connection and testing

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

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

1. Connect the ground connection from the transformer to the ground terminal on the tap-changer flange.
2. Connect the ground connection from the transformer to the ground terminal on the motor-drive mechanism.
3. Connect the motor supply and the control supply to the correct terminals on the motor-drive mechanism. See the circuit diagram supplied with the tap-changer.

**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.

2. Operate the tap-changer with the hand crank, counting the number of turns from the exact position until the tap-changer operates.
   - For BUL2 – the tap-changer should operate after 11.5 ± 1 turn of the hand crank.
   - For BUE – the tap-changer should operate after 19 ± 1.5 turns of the hand crank.

If not, one of the shaft couplings of the gears is incorrectly mounted.

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

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

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

**WARNING**
Dangerous voltage!

For a BUL2 motor-drive mechanism, continue to Step 7.

For a BUE motor-drive mechanism, continue to 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. 14.
   - 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. 15.
   - 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 BUL2**
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.
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.

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

WARNING

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

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

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

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

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

8.2 Transport preparations
Transport of the tap-changer mounted in the transformer should be prepared as described below.

8.2.1 Transport with complete transformer
In this case the oil conservator is connected to the tap-changer during transportation. The tap-changer should be filled with oil to normal operating level.

8.2.2 Transport with dismounted conservator
If the conservator is to be dismounted during transport the oil level in the tap-changer has to be lowered.

1. Connect a pump to the oil valve and suck out oil until the oil flow stops. The oil level will then be 300-400 mm below the top cover.
2. Disconnect the conservator and the pump.
3. Protect the openings with covers.

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 dehydration.

8.2.3 Protection of motor-drive
The motor-drive mechanism must be protected against condensation. Energize the heater when power is available. When not, put drying agent inside the motor drive cabinet and seal the vents.
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.

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

9.1 Reassembly
Reassemble the conservator and all other accessories which may have been dismantled for the transport. Remember the O-rings in the flanges.

The pressure relay is usually delivered in a separate package and installed at commissioning. Depending on the transport requirements, the transformer may be delivered with the motor-drive mechanism and drive-shaft system mounted or not mounted. If any shafts have been dismantled, see section 5.3 for assembly. Note especially section 5.3.2 points 8 and 9 for synchronizing. The tap-changer may be delivered filled with oil or without oil. Please use the relevant parts of this manual to carry out commissioning.

For information about tools, materials and oil required, see relevant parts in chapter 1 of this guide.

9.2 Oil filling
See chapter 6.

9.3 Electrical connection and testing
Do all wiring work and perform the appropriate tests as described in chapter 7. Remove the drying agent inside the cabinet of the motor-drive mechanism. Check that the air vents are open.

9.3.1 Motor protection
The function of the protective motor switch should be checked. For three-phase AC motors, remove one of the phase fuses and check the function time of the protective motor switch by a RAISE or LOWER operation. The protective motor switch should release within 60 seconds at a current setting equal to the rated current of the motor at the actual voltage.

**CAUTION**

If the protective motor switch has not released within 60 seconds, disconnect the power and check the settings with the rating plate of the motor. Adjust if necessary and check again when the motor has cooled down.

**WARNING**

The motor power voltage is dangerous.

Protective motor switches for DC motors and for single-phase AC motors are not tested.

9.3.2 Disc brake
For BUL2
1. Run the motor-drive mechanism.
2. 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. 14.
   If it does not stop within the tolerances, see the maintenance guide for the motor-drive mechanism.

For BUE
1. Run the motor-drive mechanism.
2. Check that the red mark on the brake disc stops within the tolerance limits. See Fig. 15.
3. 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.

9.3.3 Counter
Check that the counter functions upon RAISE and LOWER operations.

9.3.4 Position transmitter and other multi-position switches
Check the function of the position transmitter and other multi-position switches.

9.3.5 Light
Check that the light is switched on when the door is opened and goes out when the door is closed.

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9.3.6 Heater
Switch off all power supplies and feel with a finger on the protection plate that the heater has been warmed up during earlier tests. Switch on the power afterwards.

9.3.7 Pressure relay
Check the function as described in Accessories and protection devices for on-load tap-changers, 1ZSC000562-AAD.

9.4 Putting into operation
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 cabinet or on the transformer cover. Close the door to the motor-drive.