On-Load Tap-Changer
VACUTAP® VR®

Installation and Commissioning Instructions

6028604/00 EN . High-temperature version
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1 Introduction

This technical file contains detailed descriptions of the safe and proper installation, connection, and commissioning of the product.

It also includes safety instructions and general information about the product.

Information about operation can be found in the operating instructions.

This technical file is intended solely for specially trained and authorized personnel.

1.1 Manufacturer

The product is manufactured by:

Maschinenfabrik Reinhausen GmbH
Falkensteinstrasse 8
93059 Regensburg, Germany
Tel.: (+49) 9 41/40 90-0
Fax: (+49) 9 41/40 90-7001
E-mail: sales@reinhausen.com

Further information on the product and copies of this technical file are available from this address if required.

1.2 Completeness

This technical file is incomplete without the supporting documents.

The following documents are considered supporting documents:
- Unpacking instructions
- Supplement
- Routine test report
- Connection diagrams
- Dimensional drawings
- Order confirmation

1.3 Safekeeping

Keep this technical file and all supporting documents ready at hand and accessible for future use at all times.

1.4 Notation conventions

This section contains an overview of the symbols and textual emphasis used.
1.4.1 Hazard communication system

Warnings in this technical file are displayed as follows.

1.4.1.1 Warning relating to section

Warnings relating to sections refer to entire chapters or sections, sub-sections or several paragraphs within this technical file. Warnings relating to sections use the following format:

**Type of danger!**
Source of the danger and outcome.
► Action
► Action

1.4.1.2 Embedded warning information

Embedded warnings refer to a particular part within a section. These warnings apply to smaller units of information than the warnings relating to sections. Embedded warnings use the following format:

**DANGER!** Instruction for avoiding a dangerous situation.

1.4.1.3 Signal words and pictograms

The following signal words are used:

<table>
<thead>
<tr>
<th>Signal word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>DANGER</td>
<td>Indicates a hazardous situation which, if not avoided, will result in death or serious injury.</td>
</tr>
<tr>
<td>WARNING</td>
<td>Indicates a hazardous situation which, if not avoided, could result in death or serious injury.</td>
</tr>
<tr>
<td>CAUTION</td>
<td>Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.</td>
</tr>
<tr>
<td>NOTICE</td>
<td>Indicates measures to be taken to prevent damage to property.</td>
</tr>
</tbody>
</table>

Table 1: Signal words in warning notices
Pictograms warn of dangers:

<table>
<thead>
<tr>
<th>Pictogram</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Pictogram" /></td>
<td>Warning of a danger point</td>
</tr>
<tr>
<td><img src="image" alt="Pictogram" /></td>
<td>Warning of dangerous electrical voltage</td>
</tr>
<tr>
<td><img src="image" alt="Pictogram" /></td>
<td>Warning of combustible substances</td>
</tr>
<tr>
<td><img src="image" alt="Pictogram" /></td>
<td>Warning of danger of tipping</td>
</tr>
<tr>
<td><img src="image" alt="Pictogram" /></td>
<td>Warning of danger of crushing</td>
</tr>
</tbody>
</table>

Table 2: Pictograms used in warning notices

1.4.2 Information system

Information is designed to simplify and improve understanding of particular procedures. In this technical file it is laid out as follows:

Important information.

1.4.3 Instruction system

This technical file contains single-step and multi-step instructions.

Single-step instructions

Instructions which consist of only a single process step are structured as follows:
Aim of action
✓ Requirements (optional).
► Step 1 of 1.
⇒ Result of step (optional).
⇒ Result of action (optional).

Multi-step instructions
Instructions which consist of several process steps are structured as follows:
Aim of action
✓ Requirements (optional).
1. Step 1.
   ⇒ Result of step (optional).
2. Step 2.
   ⇒ Result of step (optional).
   ⇒ Result of action (optional).
2 Safety

This technical file contains detailed descriptions on the safe and proper installation, connection, commissioning and monitoring of the product.

- Read this technical file through carefully to familiarize yourself with the product.
- This technical file is a part of the product.
- Read and observe the safety instructions provided in this chapter in particular.
- Observe the warnings in this technical file in order to avoid function-related dangers.
- The product is manufactured on the basis of state-of-the-art technology. Nevertheless, risks to life and limb of the user or impairment of the product and other material assets may occur during use due to function-related dangers.

2.1 Appropriate use

The on-load tap-changer adjusts the transmission ratio of transformers without interrupting the load flow. The on-load tap-changer is designed solely for use in electrical energy systems and facilities in accordance with IEC 61936-1. If used as intended and in compliance with the requirements and conditions specified in this technical file as well as the warning notices in this technical file and attached to the on-load tap-changer, then the on-load tap-changer does not present any danger to people, property or the environment. This applies throughout service life of the product, from delivery to installation and operation through to disassembly and disposal.

The following is considered appropriate use:

- Use the on-load tap-changer only with the transformer specified in the order.
- Only use remote switching of the on-load tap-changer if the transformer is energized.
- Always operate the on-load tap-changer in conjunction with the oil cooling unit and the temperature sensors.
- Ensure that there are no installed parts above the on-load tap-changer head cover or the protective relay which either radiate heat themselves onto the on-load tap-changer head cover or protective relay or which prevent the dissipation of heat.
- The serial numbers of on-load tap-changer and on-load tap-changer accessories (drive, drive shaft, bevel gear, protective relay, etc.) must match if the on-load tap-changer and on-load tap-changer accessories are supplied as a set for one order.
- You will find the standard applicable to the on-load tap-changer and the year of issue on the nameplate.
- Operate the on-load tap-changer in accordance with this technical file, the agreed delivery conditions and technical data.
- Ensure that all necessary work is performed by qualified personnel only.
Only use the equipment and special tools included in delivery for the intended purpose and in accordance with the specifications of this technical file.

The on-load tap-changer is not intended to be used with an oil filter unit.

Permitted electrical operating conditions

In addition to the design data in accordance with the order confirmation, observe the following limits for the through-current and the step voltage:

In the standard version, the on-load tap-changer is designed for sinusoidal 50/60 Hz AC current with a curve form symmetrical to the zero axis and can switch twice the rated through-current \( I_r \) at its rated step voltage \( U_{ir} \).

Exceeding the rated step voltage \( U_{ir} \) for a short period by up to 10% is permitted if the rated through-current \( I_r \) is not exceeded.

2.2 Inappropriate use

Use is considered inappropriate if the product is used in a way other than as described in the "Appropriate use" section. In addition, observe the following:

Prohibited electrical operating conditions

All operating conditions that do not comply with the design data in accordance with the order confirmation are prohibited.

Prohibited operating conditions may arise due to short circuits as well as due to inrush current impulses when energizing transformers or other electrical machines. This applies to the affected transformer itself just as it does to transformers electrically connected in parallel or serially or other electrical machines.

Higher voltages may occur due to transformer overexcitation following load shedding, for example.

Operations outside of the permitted operating conditions can lead to injury to persons and damage to the product.

- Prevent any such operations outside of the permitted operating conditions by taking suitable measures.

2.3 Fundamental safety instructions

To prevent accidents, disruptions and damage as well as unacceptable adverse effects on the environment, those responsible for transport, installation, operation, maintenance and disposal of the product or parts of the product must ensure the following:
Personal protective equipment

Loosely worn or unsuitable clothing increases the danger of becoming trapped or caught up in rotating parts and the danger of getting caught on protruding parts. This increases the danger to life and limb.

- All necessary devices and personal protective equipment required for the specific task, such as a hard hat, safety footwear, etc. must be worn. Observe the section "Personal protective equipment" [► Section 2.5, Page 14].
- Never wear damaged personal protective equipment.
- Never wear rings, necklaces, or other jewelry.
- If you have long hair, wear a hairnet.

Work area

Untidy and poorly lit work areas can lead to accidents.

- Keep the work area clean and tidy.
- Make sure that the work area is well lit.
- Observe the applicable laws for accident prevention in the relevant country.

Working during operation

The product may only be operated in a sound, operational condition. Otherwise it poses a danger to life and limb.

- Regularly check the operational reliability of safety equipment.
- Comply with the inspection work, maintenance work and maintenance intervals described in this technical file.

Explosion protection

Highly flammable or explosive gases, vapors and dusts can cause serious explosions and fire. This increases the danger to life and limb.

- Do not install, operate or perform maintenance work on the product in areas where a risk of explosion is present.

Explosion protection

Impermissible on-load tap-change operations can lead to severe explosions and fire. This poses a danger to life and limb.

- Never actuate the motor-drive unit with the hand crank if the transformer is energized.
- Never actuate the motor-drive via the RAISE key / LOWER key on the motor-drive unit if the transformer is energized.
- Never actuate the motor-drive unit manually via the voltage regulator in the danger zone of the transformer if the transformer is energized.
- Ensure that no persons are in or enter the danger zone of the transformer during an on-load tap-change operation.
2.4 Personnel qualification

The person responsible for assembly, commissioning, operation, maintenance and inspection must ensure that the personnel are sufficiently qualified.
Electrically skilled person

The electrically skilled person has a technical qualification and therefore has the required knowledge and experience, and is also conversant with the applicable standards and regulations. The electrically skilled person is also proficient in the following:

- Can identify potential dangers independently and is able to avoid them.
- Is able to perform work on electrical systems.
- Is specially trained for the working environment in which (s)he works.
- Must satisfy the requirements of the applicable statutory regulations for accident prevention.

Electrically trained persons

An electrically trained person receives instruction and guidance from an electrically skilled person in relation to the tasks undertaken and the potential dangers in the event of inappropriate handling as well as the protective devices and safety measures. The electrically trained person works exclusively under the guidance and supervision of an electrically skilled person.

Operator

The operator uses and operates the product in line with this technical file. The operating company provides the operator with instruction and training on the specific tasks and the associated potential dangers arising from improper handling.

Technical Service

We strongly recommend having maintenance, repairs and retrofitting carried out by our Technical Service department. This ensures that all work is performed correctly. If maintenance is not carried out by our Technical Service department, please ensure that the personnel who carry out the maintenance are trained and authorized by Maschinenfabrik Reinhausen GmbH to carry out the work.

Authorized personnel

Authorized personnel are trained by Maschinenfabrik Reinhausen GmbH to carry out special maintenance.

2.5 Personal protective equipment

Personal protective equipment must be worn during work to minimize risks to health.

- Always wear the personal protective equipment required for the job at hand.
- Never wear damaged personal protective equipment.
- Observe information about personal protective equipment provided in the work area.
Personal protective equipment to be worn at all times

**Protective clothing**
Close-fitting work clothing with a low tearing strength, with tight sleeves and with no protruding parts. It mainly serves to protect the wearer against being caught by moving machine parts.

**Safety shoes**
To protect against falling heavy objects and slipping on slippery surfaces.

Special personal protective equipment for particular environments

**Safety glasses**
To protect the eyes from flying parts and splashing liquids.

**Visor**
To protect the face from flying parts and splashing liquids or other dangerous substances.

**Hard hat**
To protect from falling and flying parts and materials.

**Hearing protection**
To protect from hearing damage.

**Protective gloves**
To protect from mechanical, thermal, and electrical hazards.
3 Product description

This chapter contains an overview of the design and function of the product.

3.1 Scope of delivery

The product is packaged with protection against moisture and is usually delivered as follows:

- Oil compartment with on-load tap-changer head and built-in diverter switch insert
- Selector
- Motor-drive unit with shielding housing and controller for oil cooling unit
- Drive shaft with coupling parts and bevel gear
- Oil cooling unit with heat exchanger
- Protective devices
- Technical files

Please refer to the delivery slip for full details of scope of delivery.

Note the following information:

- Check the shipment for completeness on the basis of the shipping documents.
- Store the parts in a dry place until installation
- The product must remain in its airtight, protective wrapping and may only be removed immediately before installation

You will find more information in the "Packaging, transport, and storage" [► Section 4, Page 33] chapter.

3.2 On-load tap-changer

3.2.1 Function description

On-load tap-changers are used to adjust the transmission ratio of transformers without interrupting the load flow. Fluctuations in voltage occurring in the power transmission grid, for example, can therefore be compensated for. For this purpose, on-load tap-changers are fitted in transformers and connected to the active part of the transformer.
A motor-drive unit which receives a control impulse (e.g. from a voltage regulator) changes the operating position of the on-load tap-changer, as a result of which the transformer's transmission ratio is adapted to the prevailing operating requirements.

Figure 1: System overview of transformer on-load tap-changer

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oil conservator</td>
</tr>
<tr>
<td>2</td>
<td>On-load tap-changer</td>
</tr>
<tr>
<td>3</td>
<td>Active part of the transformer</td>
</tr>
<tr>
<td>4</td>
<td>Heat exchanger</td>
</tr>
<tr>
<td>5</td>
<td>Transformer tank</td>
</tr>
<tr>
<td>6</td>
<td>Fan</td>
</tr>
<tr>
<td>7</td>
<td>Oil cooling unit</td>
</tr>
<tr>
<td>8</td>
<td>Shielding housing</td>
</tr>
<tr>
<td>9</td>
<td>Motor-drive unit</td>
</tr>
<tr>
<td>10</td>
<td>Vertical drive shaft</td>
</tr>
<tr>
<td>11</td>
<td>Pipe (hot insulating fluid)</td>
</tr>
<tr>
<td>12</td>
<td>Pipe (cooled insulating fluid)</td>
</tr>
</tbody>
</table>
3.2.2 Design/versions

The on-load tap-changer consists of the on-load tap-changer head, oil compartment with built-in diverter switch insert and the selector mounted below (also available with change-over selector on request).

The design and designation of the most important on-load tap-changer components are shown in the installation drawings in the appendix.
For the number of maximum operating positions of the on-load tap-changer, refer to the technical data.

Figure 2: Design of VACUTAP® VR

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>On-load tap-changer head</td>
</tr>
<tr>
<td>2</td>
<td>Temperature sensor</td>
</tr>
<tr>
<td>3</td>
<td>Pipe bend</td>
</tr>
<tr>
<td>4</td>
<td>Oil compartment</td>
</tr>
<tr>
<td>5</td>
<td>Tap selector</td>
</tr>
<tr>
<td>6</td>
<td>Change-over selector (optional)</td>
</tr>
<tr>
<td>7</td>
<td>On-load tap-changer head cover</td>
</tr>
<tr>
<td>8</td>
<td>Rupture disk</td>
</tr>
<tr>
<td>9</td>
<td>Upper gear unit</td>
</tr>
</tbody>
</table>
3.2.2.1 Pipe connections

There are 5 pipe connections on the on-load tap-changer head and on-load tap-changer head cover for various purposes. Depending on the order, some or all of these pipe connections are fitted with pipe bends ex factory.

All pipe bends without terminal box for the tap-change supervisory device can be freely swiveled once the pressure ring is loosened.

Figure 3: Pipe connections with pipe bends

Pipe connection Q

The connection cable of the tap-change supervisory device delivered as an option is routed through pipe connection Q. Pipe connection Q is closed with a blank cover on the on-load tap-changer version without tap-change supervisory device.

The functions of the R and Q pipe connections can be interchanged. You must, however, use the long pipe bend on the pipe connection through which the tap-change supervisory control cable is to be threaded.

Pipe connection S

Pipe connection S is provided for returning the insulating fluid from the heat exchanger. The pipe bend on pipe connection S is equipped with a vent screw so that the pipe system can be bled.

Pipe connection R

Pipe connection R is provided for attaching the protective relay and connecting the on-load tap-changer oil conservator.

The functions of the R and Q pipe connections can be interchanged. You must, however, use the long pipe bend on the pipe connection through which the tap-change supervisory control cable is to be threaded.
Pipe connection E2

Pipe connection E2 is sealed off with a blank cover. It leads into the oil tank of the transformer, directly under the on-load tap-changer head and can be connected to a collective pipe for the Buchholz relay, if necessary. This pipe connection serves a further purpose, namely to equalize the pressure between the transformer tank and oil compartment of the on-load tap-changer, which is necessary for drying, oil filling and transportation of the transformer.

Pipe connection A

Pipe connection A in the on-load tap-changer head cover is provided for feeding the insulating fluid into the pump unit of the oil cooling unit.

3.2.3 Nameplate and serial number

The nameplate with the serial number is on the on-load tap-changer head cover.

Figure 4: Position of nameplate
The serial number can also be found on the selector.

3.2.4 Protective devices

The following protective devices for the product are included as standard in the scope of delivery or are available as options.

3.2.4.1 Protective relay

3.2.4.1.1 Function description

The protective relay is looped into the circuit breaker tripping circuit, thus protecting the on-load tap-changer and transformer in the event of a fault within the on-load tap-changer oil compartment. It is tripped when the specified speed of flow from the on-load tap-changer head to the oil conservator is exceeded due to a fault. The flowing insulating fluid actuates the flap valve which tips over into position OFF. The contact in the dry-reed magnetic switch is thereby actuated, the circuit breakers are tripped, and the transformer is de-energized.

The protective relay is a component of an on-load tap-changer filled with insulating fluid and its properties conform to the respective applicable version of IEC publication 60214-1.

Diverter switch operations at rated switching capacity or at permissible overload will not cause the protective relay to trip.
3 Product description

The protective relay responds to flow, not to gas accumulated in the protective relay. It is not necessary to bleed the protective relay when filling the transformer with insulating fluid. Gas accumulation in the protective relay is normal.

3.2.4.1.2 Design/versions

**Front view**

![Figure 6: Protective relay RS 2001/T](image)

1. Inspection window
2. Pressure equalization element

**Rear view**

![Figure 7: Protective relay RS 2001/T](image)

1. Dummy plug
2. Nameplate
3.2.4.1.3 Nameplate

The nameplate is on the back of the protective relay.
3.2.4.1.4 Safety markings

The following safety markings in accordance with DIN EN 60255-27 are used on the product:

![Figure 10: Overview of safety markings](image)

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Protective conductor connection</td>
</tr>
<tr>
<td>2</td>
<td>Notice, danger of electric shock</td>
</tr>
<tr>
<td>3</td>
<td>Notice, observe the documentation</td>
</tr>
</tbody>
</table>

3.2.4.2 Rupture disk

The rupture disk is a pressure relief device without signaling contact in accordance with IEC 60214-1 and is located in the on-load tap-changer head cover.

The rupture disk responds to a defined overpressure in the oil compartment of the on-load tap-changer.

3.2.4.3 Tap-change supervisory device

The tap-change supervisory device monitors both the drive shaft between on-load tap-changer(s) and motor-drive unit and the correct switching of the diverter switch.

3.2.4.4 Temperature monitoring

The temperature monitoring system monitors, controls and records the temperature of the insulating fluid in the oil compartment of the on-load tap-changer.

The controller of the temperature monitoring system is integrated into the motor-drive unit.

You will find further information on temperature monitoring in the operating instructions for the motor-drive unit and oil cooling unit.
3.3 Drive shaft

3.3.1 Function description

The drive shaft is the mechanical connection between motor-drive and on-load tap-changer head / de-energized tap-changer head.

The bevel gear changes the direction from vertical to horizontal.

Accordingly, the vertical drive shaft has to be mounted between drive and bevel gear, and the horizontal drive shaft between bevel gear and on-load tap-changer or de-energized tap-changer.
3.3.2 Design/versions

The drive shaft consists of a square tube and is coupled at each end by two coupling brackets and one coupling bolt to the driving or driven shaft end of the device to be connected.

![Diagram of drive shaft components](image)

**Figure 11: Components of the drive shaft**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bevel gear</td>
</tr>
<tr>
<td>2</td>
<td>Hose clip</td>
</tr>
<tr>
<td>3</td>
<td>Telescopic protective tube</td>
</tr>
<tr>
<td>4</td>
<td>Coupling bracket</td>
</tr>
<tr>
<td>5</td>
<td>Square tube</td>
</tr>
<tr>
<td>6</td>
<td>Coupling bolt</td>
</tr>
<tr>
<td>7</td>
<td>Adapter ring</td>
</tr>
<tr>
<td>8</td>
<td>Protective cover</td>
</tr>
<tr>
<td>9</td>
<td>Hose clip</td>
</tr>
</tbody>
</table>
3.3.2.1 Drive shaft without cardan joint and without insulator

Figure 12: Drive shaft without cardan joint and without insulator (= standard version)

<table>
<thead>
<tr>
<th>Configuration</th>
<th>V 1 min</th>
<th>Intermediate bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle of hand crank – middle of bevel gear (maximum permissible axial offset 2°)</td>
<td>536 mm</td>
<td>When the maximum value of 2472 mm is exceeded, it is necessary to use an intermediate bearing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V 1 ≤ 2472 mm (without intermediate bearing)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V 1 &gt; 2472 mm (with intermediate bearing)</td>
</tr>
</tbody>
</table>
3 Product description

3.3.2.2 Drive shaft without cardan joint and with insulator

**Figure 13: Drive shaft without cardan joint and with insulator (= special model)**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>V 1 min</th>
<th>Intermediate bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle of hand crank – middle of bevel gear (maximum permissible axial offset 2°)</td>
<td>706 mm</td>
<td>When the maximum value of 2472 mm is exceeded, it is necessary to use an intermediate bearing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V 1 ≤ 2472 mm (without intermediate bearing)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V 1 &gt; 2472 mm (with intermediate bearing)</td>
</tr>
</tbody>
</table>

3.3.2.3 Drive shaft with cardan joints, without insulator

An axial displacement of maximum 20° to the side facing away from the transformer is permitted for the vertical drive shaft with cardan joints. An axial displacement of maximum 2° to the side facing the transformer is permitted.
3.3.2.4 Drive shaft with cardan joint and with insulator

An axial displacement of maximum 20° to the side facing away from the transformer is permitted for the vertical drive shaft with cardan joints and insulator. An axial displacement of maximum 2° to the side facing the transformer is permitted.
Figure 15: Drive shaft with cardan joint and with insulator (= special model)

<table>
<thead>
<tr>
<th>Configuration</th>
<th>V 1 min [mm]</th>
<th>Intermediate bearing for [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle of hand crank – middle of bevel gear</td>
<td>978</td>
<td>V 1 &gt; 2772</td>
</tr>
</tbody>
</table>
3.3.3 Identification plate

The identification plate is on the telescopic protective tube.

Figure 16: Position of the identification plate
4 Packaging, transport and storage

4.1 Packaging

The products are sometimes supplied with sealed packaging and sometimes in a dry state, depending on requirements.

Sealed packaging surrounds the packaged goods with plastic foil on all sides.

Products that have also been dried are identified by a yellow label on the sealed packaging. In the dry state, delivery is also possible in a transport container.

The information in the following sections should be applied as appropriate.

4.1.1 Suitability

**NOTICE**

Property damage due to incorrectly stacked crates!

Stacking the crates incorrectly can lead to damage to the packaged goods.

► The outer marking on the packaging states if, for example, the on-load tap-changer or selector has been packed upright. Never stack these crates.

► General rule: Do not stack crates above a height of 1.5 m.

► For other crates: Only stack up to 2 equally sized crates on top of one another.

The packaging is suitable to ensure undamaged and fully functional means of transportation in compliance with local transportation laws and regulations.

The packaged goods are packed in a sturdy crate. This crate ensures that, when in the intended transportation position, the packaged goods are stabilized to prevent impermissible changes in position, and that none of the parts touch the loading surface of the means of transport or touch the ground after unloading.

Sealed packaging surrounds the packaged goods with plastic foil on all sides. The packaged goods are protected from humidity using a desiccant. The plastic foil was bonded after the desiccant is added.
4.1.2 Markings

The packaging bears a signature with instructions for safe transport and correct storage. The following symbols apply to the shipment of non-hazardous goods. Adherence to these symbols is mandatory.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Symbol" /></td>
<td>Protect against moisture</td>
</tr>
<tr>
<td><img src="image2" alt="Symbol" /></td>
<td>Top</td>
</tr>
<tr>
<td><img src="image3" alt="Symbol" /></td>
<td>Fragile</td>
</tr>
<tr>
<td><img src="image4" alt="Symbol" /></td>
<td>Attach lifting gear here</td>
</tr>
<tr>
<td><img src="image5" alt="Symbol" /></td>
<td>Center of mass</td>
</tr>
</tbody>
</table>

Table 3: Shipping pictograms

4.2 Transportation, receipt and handling of shipments

**WARNING**

Danger of death and damage to property!

Danger of death and damage to property due to tipping or falling load.

- Only transport the crate when closed.
- Do not remove the securing material used in the crate during transport.
- If the product is delivered on a pallet, secure it sufficiently.
- Only trained and authorized persons may select the sling gear and secure the load.
- Do not walk under the hanging load.
- Use means of transport and lifting gear with a sufficient carrying capacity in accordance with the weight stated on the delivery slip.

In addition to oscillation stress, jolts must also be expected during transportation. In order to prevent possible damage, avoid dropping, tipping, knocking over and colliding with the product.

If a crate tips over, falls from a certain height (e.g. when slings tear) or is subject to an unbroken fall, damage must be expected regardless of the weight.

Every delivered shipment must be checked for the following by the recipient before acceptance (acknowledgment of receipt):

- Completeness based on the delivery slip
- External damage of any type

The checks must take place after unloading when the crate or transport container can be accessed from all sides.
4 Packaging, transport and storage

**Visible damage**  If external transport damage is found upon receipt of the shipment, proceed as follows:

- Immediately record the identified transport damage in the shipping documents and have this countersigned by the carrier.
- In the event of severe damage, total loss or high damage costs, immediately notify the manufacturer and the relevant insurance company.
- After identifying damage, do not modify the condition of the shipment further and retain the packaging material until an inspection decision has been made by the transport company or the insurance company.
- Record the details of the damage immediately on site together with the carrier involved. This is essential for any claim for damages.
- Photograph damage to packaging and packaged goods. This also applies to signs of corrosion on the packaged goods due to moisture inside the packaging (rain, snow, condensation).
- **NOTICE!** If the product is delivered in sealed packaging, inspect this immediately. If the sealed packaging is damaged, do not under any circumstances install or commission the packaged goods. Either re-dry the dried packaged goods as per the operating instructions, or contact the manufacturer to agree on how to proceed. Failure to do so may result in damage to the packaged goods.
- Identify the damaged parts.

**Hidden damage**  When damages are not determined until unpacking after receipt of the shipment (hidden damage), proceed as follows:

- Make the party responsible for the damage liable as soon as possible by telephone and in writing, and prepare a damage report.
- Observe the time periods applicable to such actions in the respective country. Inquire about these in good time.

With hidden damage, it is very hard to make the transportation company (or other responsible party) liable. Any insurance claims for such damages can only be successful if relevant provisions are expressly included in the insurance terms and conditions.

### 4.3 Storage of shipments

**Packaged goods dried by Maschinenfabrik Reinhausen**

Upon receipt of the shipment, immediately remove the packaged goods dried by Maschinenfabrik Reinhausen from the sealed packaging and store air-tight in dry insulating oil until used if the packaged goods were not supplied in oil.

**Non-dried packaged goods**

Non-dried packaged goods but with a functional sealed packaging can be stored outdoors when the following conditions are complied with.
When selecting and setting up the storage location, ensure the following:

▪ Protect stored goods against moisture (flooding, water from melting snow and ice), dirt, pests such as rats, mice, termites and so on, and against unauthorized access.

▪ Store the crates on timber beams and planks as a protection against rising damp and for better ventilation.

▪ Ensure sufficient carrying capacity of the ground.

▪ Keep entrance paths free.

▪ Check stored goods at regular intervals. Also take appropriate action after storms, heavy rain or snow and so on.

Protect the packaging foil from direct sunlight so that it does not disintegrate under the influence of UV rays, which would cause the packaging to lose its sealing function.

If the product is installed more than 6 months after delivery, suitable measures must be taken without delay. The following measures can be used:

▪ Correctly regenerate the drying agent and restore the sealed packaging.

▪ Unpack the packed goods and store in a suitable storage space (well ventilated, as dust-free as possible, humidity < 50% where possible).

4.4 Unpacking shipments and checking for transportation damages

▪ **NOTICE!** Transport the packaged crate to the place where installation will take place. Do not open the sealed packaging until just before installation. If this is not done, damage to the packaged goods may occur due to ineffectively sealed packaging.

▪ **WARNING!** When unpacking, check the condition of the packaged goods. Secure packaged goods in an upright crate from tipping out. If this is not done, the packaged goods may be damaged and serious injuries may result.

▪ Check completeness of supplementary parts on the basis of the delivery slip.
5 Mounting

**Risk of crushing!**

When the on-load tap-changer undertakes a tap-change operation, components – some of which are freely accessible – move on the selector, change-over selector, and potential connection unit. Reaching into the selector, change-over selector, or potential connection unit during a tap-change operation may result in serious injuries.

► Keep a safe distance of at least 1 m during tap-change operations.
► Do not reach into the selector, change-over selector, or potential connection unit during tap-change operations.
► Do not switch the on-load tap-changer when working on the selector, change-over selector, or potential connection unit.

This chapter describes how to install the on-load tap-changer in a transformer and how to dry it, and also how to mount the protective devices and drive components.

5.1 Preparatory work

Perform the work stated below before installing the on-load tap-changer in the transformer.
5.1.1 Fitting mounting flange on transformer cover

A mounting flange is required for fitting the on-load tap-changer head on the transformer cover. This can be supplied as an option or can be produced by the customer. Mounting flanges made by the customer must comply with the installation drawings in the appendix.

**NOTICE!** Fit mounting flange on transformer cover (pressure tight). Ensure that the sealing face makes complete contact and is not damaged.

![Figure 17: Mounting flange](image)

5.1.2 Fitting stud bolts on mounting flange

To attach the stud bolts to the mounting flange, use a tracing template. This can be provided upon request free of charge for the initial installation of the on-load tap-changer.

1. Place tracing template on mounting flange and use the four markings to align.
5 Mounting

2. Fit stud bolts on mounting flange.

![Tracing template, stud bolts](image)

Figure 18: Tracing template, stud bolts

5.2 Installing the on-load tap-changer in the transformer (standard version)

Perform the work stated below in order to install the on-load tap-changer in the transformer (standard version).

5.2.1 Fastening on-load tap-changer to transformer cover

This chapter describes how to fasten the on-load tap-changer to the transformer cover.
5.2.1.1 Fastening oil compartment on transformer cover

To fasten the oil compartment to the transformer cover, proceed as follows:

1. **CAUTION!** An unstably positioned oil compartment may tip over, resulting in injuries or property damage. Place the oil compartment on a level surface and secure it against tipping.

![Figure 19: Oil compartment](image)

2. Remove red-colored packaging material and transport material from the oil compartment.
3. **NOTICE!** Unsuitable gaskets lead to insulating fluid escaping and therefore to damage to the on-load tap-changer. Place a gasket suitable for the insulating fluid used and the application on the mounting flange. Clean the sealing surfaces on the mounting flange and on-load tap-changer head.

Figure 20: Sealing surfaces, gasket
4. **NOTICE!** Lowering the oil compartment without due care can result in the oil compartment colliding with the transformer cover and becoming damaged. Lift the oil compartment by hooking up the on-load tap-changer head and carefully lower it vertically into the opening of the transformer cover.

![Figure 21: Lowering oil compartment](image)

5. Check that the on-load tap-changer head is mounted in the position specified by the design.
6. Screw the on-load tap-changer head to the mounting flange.

7. Remove the blocking strip from the coupling of the oil compartment base.

Figure 22: On-load tap-changer head with mounting flange

Figure 23: Oil compartment base with blocking strip
5.2.1.2 Securing selector to oil compartment

1. **CAUTION!** An unstably positioned selector may tip, resulting in injuries or property damage. Place the selector on a level surface and secure it against tipping.

2. Remove red-colored packaging material and transport material from the selector. Only remove the red protective cap on the 0-bar of the changeover selector after fixing the selector to the oil compartment.

3. Remove plastic bag with fastening materials from the selector and keep it ready.

![Figure 24: Plastic bag with fastening materials](image)
4. Remove the blocking strip from the selector coupling. Once the blocking strip is removed, the selector coupling may no longer be turned.

Figure 25: Selector coupling with blocking strip

5. Place the selector on the lifting device. The weight of the selector is a maximum of 180 kg.

6. **NOTICE!** Lifting the selector without due care can result in the selector and oil compartment colliding and becoming damaged. Carefully lift selector below the oil compartment, ensuring that the tap-selector connecting leads are free when lifting the selector on the oil compartment and do not touch the compartment.

7. Align the position of both coupling parts and attachment points on the oil compartment and the selector with one another. The correct position of the two coupling parts is shown in the adjustment plans supplied.
8. Screw selector bracket onto oil compartment.

Figure 26: Oil compartment and selector screwed down
9. **NOTICE!** Incorrect tightening torques and unsecured screw connections can lead to damage to the on-load tap-changer. Screw the tap-selector connecting leads to connecting piece with care. Comply with the specified tightening torque, secure screw connections and snap the screening caps in place over the screw heads.

Figure 27: Tap-selector connecting leads
10. Remove the red protective cap on the 0-bar of the change-over selector.

![Figure 28: Protective cap](image)

### 5.2.2 Connecting the tap winding and on-load tap-changer take-off lead

**NOTICE**

**Damage to the on-load tap-changer!**

Connecting leads that place mechanical strain on the on-load tap-changer will damage the on-load tap-changer.

- Establish connections carefully.
- Do not twist connection contacts.
- Connect connecting leads without warping or deforming.
- If necessary, use an expansion loop for connecting leads.
- Fit screening caps provided to screw connections.

The tap winding and on-load tap-changer take-off lead must be connected in accordance with the connection diagram included with the delivery.
5.2.2.1 Tap selector connection contacts

The tap selector connection contacts are provided with a through-hole for M10 screws. The through-holes are either horizontal or vertical, depending on the on-load tap-changer model.

1. Fasten the tap-winding connecting leads to the tap selector in accordance with the connection diagram provided. The cable shoes and fastening materials are not included in the scope of delivery.

2. Take suitable measures to ensure that each fitting cannot come loose or settle (e.g. by using clamping washers). Be sure to attach the screening caps as shown in the illustration if these are included in the delivery scope.

3. Close the screening caps and make sure they are seated correctly. The screw head and nut must be fully covered.

Figure 29: Tap selector connection contacts

5.2.2.2 Change-over selector connection contacts for reversing change-over selector connection

**NOTICE**

Damage to the on-load tap-changer!

Tap-winding connecting leads situated too closely to the change-over selector’s moving parts block the change-over selector and therefore result in damage to the on-load tap-changer.

- Tap-winding connecting leads in the area of the change-over selector have to be routed such that they are at a sufficient distance from the change-over selector’s moving parts.
The (+) and (-) change-over selector connection contacts are designed as connecting lugs with through-holes for M10 screws for reversing change-over selector connection.

The connection contact K is designed as an extended tap selector connection contact with through-hole for M10 screws.

1. Fasten the tap-winding connecting leads to the change-over selector in accordance with the connection diagram provided. The cable shoes and fastening materials are not included in the scope of delivery.
2. Take suitable measures to ensure that each fitting cannot come loose or settle (e.g. by using clamping washers). Be sure to attach the screening caps if these are included in the delivery scope.
3. Close the screening caps and make sure they are seated correctly. The screw head and nut must be fully covered.

Figure 30: Change-over selector connection contacts for reversing change-over selector connection
5.2.2.3 Change-over selector connection contacts for coarse tap selector connection

**NOTICE**

**Damage to the on-load tap-changer!**

Tap-winding connecting leads situated too closely to the change-over selector’s moving parts block the change-over selector and therefore result in damage to the on-load tap-changer.

- Tap-winding connecting leads in the area of the change-over selector have to be routed such that they are at a sufficient distance from the change-over selector’s moving parts.

With coarse tap selector connection, the external appearance of the (+) and (-) change-over selector connection contacts is identical to the tap selector contacts (through-hole for M10 screws, always in vertical position).

1. Fasten the tap-winding connecting leads to the change-over selector in accordance with the connection diagram provided. The cable shoes and fastening materials are not included in the scope of delivery.

2. Take suitable measures to ensure that each fitting cannot come loose or settle (e.g. by using clamping washers). Be sure to attach the screening caps if these are included in the delivery scope.
3. Close the screening caps and make sure they are seated correctly. The screw head and nut must be fully covered.

Figure 32: Change-over selector connection contacts for coarse tap selector connection

Figure 33: Change-over selector connection contacts for coarse tap selector connection (top view)

5.2.2.4 Connecting on-load tap-changer take-off lead

There are through-holes 13 mm in diameter at several points in the take-off ring of the oil compartment for connecting the on-load tap-changer take-off lead.
To connect the on-load tap-changer take-off lead, proceed as follows:

1. Connect the on-load tap-changer take-off lead to any through-hole on the take-off ring using the cable shoe and screw. The cable shoe and fastening materials are not included in the scope of delivery.

2. Take suitable measures to ensure the screw connection cannot come loose or settle (e.g. by using clamping washers).

Figure 34: Take-off ring on oil compartment
5.2.3 Performing transformer ratio test before drying

**NOTICE**

**Damage to the on-load tap-changer!**

Damage to the on-load tap-changer due to transformer ratio test being incorrectly performed.

- Do not perform more than 250 tap-change operations on the on-load tap-changer. If more than 250 tap-change operations are to be performed, completely fill the oil compartment with insulating fluid and lubricate sliding surfaces of contacts on the selector and selector gear with insulating fluid.

- Only switch the on-load tap-changer from one operating position to the next via the upper gear unit. You can use a short tube (diameter 25 mm) with screwed-in coupling bolt (diameter 12 mm) with a hand wheel or crank for this, for example. When using a drill, do not exceed a maximum speed of 250 rpm.

- Always check the operating position reached through the inspection window in the on-load tap-changer head cover. Never overshoot the end positions, which are indicated in the connection diagram supplied with the delivery.

- For multiple-column applications with a shared drive, link all on-load tap-changer heads to one another using the horizontal drive shaft parts.

When actuating the change-over selector, a higher torque is required.

To perform the transformer ratio test, proceed as follows:

1. Switch the on-load tap-changer into the desired operating position. The diverter switch operation can be heard distinctly.

2. **NOTICE!** An incomplete tap-change operation may damage the on-load tap-changer. After operating the diverter switch, continue to crank the drive shaft of the upper gear unit for 2.5 revolutions in the same direction in order to correctly complete the tap-change operation.

3. Perform the transformer ratio test.

4. Repeat the transformer ratio test in all operating positions.

5. Once the transformer ratio test is complete, return on-load tap-changer to its adjustment position (see supplied connection diagram of the on-load tap-changer).

After the transformer ratio test, open the kerosene drain plug in the oil compartment if the on-load tap-changer is to be dried with kerosene in the transformer tank. After drying, the diverter switch insert must be removed, the kerosene drain plug in the oil compartment closed and the diverter switch insert refitted.
5.2.4 Performing DC resistance measurement on transformer

Note the measurement scenarios listed below and the associated maximum measured currents when performing DC resistance measurement on the transformer.

The measured DC current is normally restricted to 10% of the rated current of the measured transformer winding in order to prevent the winding from overheating.

Perform the DC resistance measurement in various on-load tap-changer operating positions. You need to distinguish here whether the measured current is interrupted when changing operating position or not.

<table>
<thead>
<tr>
<th>Status of oil compartment</th>
<th>Without interruption in measured current</th>
<th>With interruption (measured current = 0 A before change in operating position)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil compartment empty</td>
<td>Maximum 10 A DC</td>
<td>Maximum 50 A DC</td>
</tr>
<tr>
<td>Oil compartment filled with insulating fluid</td>
<td>Maximum 50 A DC</td>
<td>Maximum 50 A DC</td>
</tr>
</tbody>
</table>

Table 4: Maximum permitted measured currents when performing DC resistance measurement on transformer

5.2.5 Drying on-load tap-changer in autoclave

**NOTICE**

Damage to the on-load tap-changer!

Moisture in the oil compartment reduces the dielectric strength of the insulating fluid and thus leads to damage to the on-load tap-changer.

► Within 10 hours of drying, seal off oil compartment with on-load tap-changer head cover.

Dry on-load tap-changer in accordance with the following instructions to ensure the dielectric values assured by MR for the on-load tap-changer.

If drying in an autoclave, the following methods are possible:

- Vacuum drying
- Vapor-phase drying

As an alternative to drying the on-load tap-changer in an autoclave, it can also be dried in the transformer tank.

5.2.5.1 Vacuum-drying in the autoclave

To vacuum-dry the on-load tap-changer in the autoclave, proceed as follows.

If you wish to perform another transformer ratio test after drying, proceed as described in the section "Performing transformer ratio test following drying" [► Section 5.2.8, Page 87].
5.2.5.1.1 Moving on-load tap-changer to adjustment position

► Move the on-load tap-changer into the adjustment position (see supplied connection diagram of the on-load tap-changer).

Figure 35: Adjustment position

5.2.5.1.2 Removing on-load tap-changer head cover

⚠️ WARNING

Danger of explosion!

Explosive gases under the on-load tap-changer head cover can deflagrate or explode and result in severe injury or death.

► Ensure that there are no ignition sources such as open flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.

► De-energize all auxiliary circuits (for example tap-change supervisory device, pressure relief device, pressure monitoring device) before removing the on-load tap-changer head cover.

► Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).

NOTICE

Damage to the on-load tap-changer!

Small parts in the oil compartment may block the diverter switch insert, thereby damaging the on-load tap-changer.

► Ensure that parts do not fall into the oil compartment.

► Check that all small parts are accounted for.

1. Ensure that the inspection window is sealed off with the cover.
2. Remove the screws and washers from the on-load tap-changer head cover.

![Figure 36: On-load tap-changer head cover](image)

3. Remove on-load tap-changer head cover.

![Figure 37: On-load tap-changer head cover](image)

5.2.5.1.3 Drying the on-load tap-changer

**NOTICE**

Damage to the on-load tap-changer head cover and on-load tap-changer accessories.

Both the on-load tap-changer head cover and the on-load tap-changer accessories will become damaged if they are dried in an autoclave.

- Keep the on-load tap-changer head cover and the following accessories outside the autoclave and never dry them with the on-load tap-changer: motor-drive unit, drive shaft, protective relay, pressure monitoring device, pressure relief device, bevel gear, temperature sensor, oil filter unit.

1. Heat up the on-load tap-changer in air at atmospheric pressure with a temperature increase of approximately 10°C/h to a final temperature of maximum 110°C.

2. Pre-dry the on-load tap-changer in circulating air at a maximum temperature of 110°C for a period of at least 20 hours.

3. Vacuum-dry on-load tap-changer at between 105°C and maximum 125°C for at least 50 hours.
4. Residual pressure of no more than $10^{-3}$ bar.

5.2.5.1.4 Securing on-load tap-changer head cover

**NOTICE**

**Damage to the on-load tap-changer!**

A missing or damaged o-ring as well as unclean sealing surfaces lead to insulating fluid escaping and therefore to damage to the on-load tap-changer.

► Ensure that the o-ring is positioned untwisted in the on-load tap-changer head cover.

► Ensure that the o-ring does not become damaged when mounting the cover.

► Ensure that the sealing surfaces on the on-load tap-changer head cover and on-load tap-changer head are clean.

1. Check that the feather key is securely positioned in the adapter shaft. Where necessary, use Vaseline to secure the feather key against falling out.

Figure 38: Feather key
2. Position the on-load tap-changer head cover on the on-load tap-changer head in such a way that the red triangular markings on the on-load tap-changer head and the on-load tap-changer head cover are aligned.

![Figure 39: On-load tap-changer head cover with o-ring](image)

3. Screw the on-load tap-changer head cover onto the on-load tap-changer head.

![Figure 40: On-load tap-changer head cover](image)

5.2.5.2 Vapor-phase drying in the autoclave

To dry the on-load tap-changer with kerosene in the autoclave, proceed as follows.
If you wish to perform another transformer ratio test after drying, proceed as described in the section "Performing transformer ratio test following drying" [Section 5.2.8, Page 87].

5.2.5.2.1 Moving on-load tap-changer to adjustment position

► Move the on-load tap-changer into the adjustment position (see supplied connection diagram of the on-load tap-changer).

Figure 41: Adjustment position

5.2.5.2.2 Removing on-load tap-changer head cover

⚠️ WARNING

Danger of explosion!

Explosive gases under the on-load tap-changer head cover can deflagrate or explode and result in severe injury or death.

► Ensure that there are no ignition sources such as open flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.

► De-energize all auxiliary circuits (for example tap-change supervisory device, pressure relief device, pressure monitoring device) before removing the on-load tap-changer head cover.

► Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).

NOTICE

Damage to the on-load tap-changer!

Small parts in the oil compartment may block the diverter switch insert, thereby damaging the on-load tap-changer.

► Ensure that parts do not fall into the oil compartment.

► Check that all small parts are accounted for.

1. Ensure that the inspection window is sealed off with the cover.
5 Mounting

2. Remove the screws and washers from the on-load tap-changer head cover.

![Figure 42: On-load tap-changer head cover](image)

3. Remove on-load tap-changer head cover.

![Figure 43: On-load tap-changer head cover](image)
5.2.5.2.3 Opening kerosene drain plug

> NOTICE! Unscrew kerosene drain plug between oil compartment base and selector gear clockwise until it starts to offer resistance to turning. Never unscrew the kerosene drain plug all the way.

![Kerosene drain plug](image)

5.2.5.2.4 Drying the on-load tap-changer

**NOTICE**

Damage to the on-load tap-changer head cover and on-load tap-changer accessories.

Both the on-load tap-changer head cover and the on-load tap-changer accessories will become damaged if they are dried in an autoclave.

> Keep the on-load tap-changer head cover and the following accessories outside the autoclave and never dry them with the on-load tap-changer: motor-drive unit, drive shaft, protective relay, pressure monitoring device, pressure relief device, bevel gear, temperature sensor, oil filter unit.

1. Supply kerosene vapor at a temperature of around 90°C. Keep this temperature constant for 3 to 4 hours.
2. Increase the kerosene vapor temperature by approx. 10°C/hour to the desired final temperature of max. 125°C at the on-load tap-changer.
3. Vacuum-dry on-load tap-changer at between 105°C and maximum 125°C for at least 50 hours.
4. Residual pressure of no more than 10⁻³ bar.

5.2.5.2.5 Closing kerosene drain plug

> NOTICE! An open kerosene drain plug leads to insulating fluid escaping from the oil compartment and therefore to damage to the on-load tap-changer. Close kerosene drain plug (tightening torque 20 Nm).
5.2.5.2.6 Securing on-load tap-changer head cover

**NOTICE**

**Damage to the on-load tap-changer!**

A missing or damaged o-ring as well as unclean sealing surfaces lead to insulating fluid escaping and therefore to damage to the on-load tap-changer.

► Ensure that the o-ring is positioned untwisted in the on-load tap-changer head cover.

► Ensure that the o-ring does not become damaged when mounting the cover.

► Ensure that the sealing surfaces on the on-load tap-changer head cover and on-load tap-changer head are clean.

1. Check that the feather key is securely positioned in the adapter shaft. Where necessary, use Vaseline to secure the feather key against falling out.

![Figure 45: Feather key](image-url)
2. Position the on-load tap-changer head cover on the on-load tap-changer head in such a way that the red triangular markings on the on-load tap-changer head and the on-load tap-changer head cover are aligned.

Figure 46: On-load tap-changer head cover with o-ring

3. Screw the on-load tap-changer head cover onto the on-load tap-changer head.

Figure 47: On-load tap-changer head cover

5.2.6 Drying on-load tap-changer in transformer tank

Dry on-load tap-changer in accordance with the following instructions to ensure the dielectric values assured by MR on the on-load tap-changer.

If you want to dry the on-load tap-changer in the transformer tank, fully assemble the transformer first and then undertake drying.
5 Mounting

If drying in the transformer tank, the following methods are possible:

- Vacuum-drying
- Vapor-phase drying

As an alternative to drying the on-load tap-changer in the transformer tank, it can also be dried in an autoclave.

5.2.6.1 Vacuum-drying in the transformer tank

To vacuum-dry the on-load tap-changer in the transformer tank, proceed as follows.

The on-load tap-changer head cover remains closed during the entire drying process.

1. Establish a connecting lead either between connections E2 and Q or connections E2 and R on the on-load tap-changer head.
2. Seal off unused pipe connections with a suitable blank cover.

![Figure 48: Connecting lead](image)

Vacuum-drying in the transformer tank

1. Heat up the on-load tap-changer in air at atmospheric pressure with a temperature increase of approximately 10°C/h to a final temperature of maximum 110°C.
2. Pre-dry the on-load tap-changer in circulating air at a maximum temperature of 110°C for a period of at least 20 hours.
3. Vacuum-dry on-load tap-changer at between 105°C and maximum 125°C for at least 50 hours.
4. Residual pressure of no more than $10^{-3}$ bar.

If you wish to perform another transformer ratio test after drying, proceed as described in the section "Performing transformer ratio test following drying" [Section 5.2.8, Page 87].
5.2.6.2 Vapor-phase drying in the transformer tank

If you have not opened the kerosene drain plug in advance (e.g. after the transformer ratio test), you have to open the kerosene drain plug before the vapor-phase drying process so that the kerosene condensate can drain from the oil compartment.

The kerosene drain plug is located in the oil compartment base and is not accessible with the diverter switch insert installed and the transformer tank closed. For this reason, you first have to remove the diverter switch insert, open the kerosene drain plug, and then install the diverter switch insert again. After the drying process, you have to remove the diverter switch insert again to close the kerosene drain plug.

5.2.6.2.1 Removing diverter switch insert

To remove the diverter switch insert, proceed as follows.

5.2.6.2.1.1 Moving on-load tap-changer to adjustment position

► Move the on-load tap-changer into the adjustment position (see supplied connection diagram of the on-load tap-changer).

![Figure 49: Adjustment position](image)

5.2.6.2.1.2 Removing on-load tap-changer head cover

**Danger of explosion!**

Explosive gases under the on-load tap-changer head cover can deflagrate or explode and result in severe injury or death.

► Ensure that there are no ignition sources such as open flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.

► De-energize all auxiliary circuits (for example tap-change supervisory device, pressure relief device, pressure monitoring device) before removing the on-load tap-changer head cover.

► Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).
**NOTICE**

Damage to the on-load tap-changer!

Small parts in the oil compartment may block the diverter switch insert, thereby damaging the on-load tap-changer.

► Ensure that parts do not fall into the oil compartment.
► Check that all small parts are accounted for.

1. Ensure that the inspection window is sealed off with the cover.
2. Remove the screws and washers from the on-load tap-changer head cover.

![Figure 50: On-load tap-changer head cover](image)

3. Remove on-load tap-changer head cover.

![Figure 51: On-load tap-changer head cover](image)
5.2.6.2.1.3 Removing tap position indicator disk

- Pull spring clip off shaft end and remove tap position indicator disk.

![Figure 52: Tap position indicator disk](image)

5.2.6.2.1.4 Removing the tap-change supervisory device

**NOTICE**

**Damage to the tap-change supervisory device!**

Removing the tap-change supervisory device without due care may damage the tap-change supervisory device, thereby resulting in damage to the on-load tap-changer.

- Remove the tap-change supervisory device with care in order not to damage or rip out the connecting leads.

1. Take the tap-change supervisory device plug connector out of the mounting bracket and disconnect it.

![Figure 53: Plug connector](image)
2. Remove nuts and locking elements on the mounting plate.

Figure 54: Mounting plate

3. Remove mounting plate with tap-change supervisory device and drive shaft.

Figure 55: Mounting plate with tap-change supervisory device and drive shaft
4. Swivel lead of the tap-change supervisory device out of the on-load tap-changer head in the direction of the arrow.

![Figure 56: Lead of tap-change supervisory device](image)

**5.2.6.2.1.5 Removing return pipe on VACUTAP VR®**

**Removal for head version 1 and 2**

1. Remove both hexagon nuts from the studs on the holder brackets.

![Figure 57: Return pipe for head version 1 and 2](image)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>On-load tap-changer head</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Pipe connection $S$</td>
<td>4A</td>
</tr>
<tr>
<td></td>
<td>4B</td>
<td></td>
</tr>
</tbody>
</table>

2. For version with tap-change supervisory control: also unscrew spacer bolts (if present).
3. Remove the washers and holder brackets in succession.
4. Pull return pipe out of hole.

**Removal for head version 3**

1. Remove hexagon nuts from studs of holder brackets and plates (retaining plate or tap-change supervisory control plate).
5.2.6.2.1.6 Lifting out diverter switch insert

1. **CAUTION!** Danger of lacerations when turning the coupling tube without an operating wrench. If the markings on the coupling flange and on-load tap-changer head are not aligned, turn the coupling tube so that the markings align, either by directly turning the shielding ring while wearing gloves or by using an operating wrench.

2. Insert the lifting gear in the eyebolts of the coupling tube and position vertically above the diverter switch insert.
3. Lift the diverter switch insert slowly and vertically out of oil compartment, ensuring that the protective ring on the indicator drive shaft does not become detached when doing so.

4. **CAUTION!** An unstably positioned diverter switch insert may tip, resulting in injuries or property damage. Place the diverter switch insert on a level surface and secure it against tipping. Do not operate the diverter switch insert or change the position of the selector coupling when the diverter switch insert is not installed.
5.2.6.2.2 Opening kerosene drain plug

► NOTICE! Unscrew kerosene drain plug with extended socket wrench counter-clockwise until it starts to offer resistance to turning. Never unscrew the kerosene drain plug all the way.

Figure 64: Kerosene drain plug

5.2.6.2.3 Inserting diverter switch insert

Proceed as follows to fit the diverter switch insert.

5.2.6.2.3.1 Inserting diverter switch insert

1. To fit the diverter switch insert, ensure that the selector coupling is in the adjustment position.

Figure 65: Adjustment markings in oil compartment base
2. **NOTICE!** Damage to the on-load tap-changer by mixing up the diverter switch inserts. Ensure that there are the same number of markings on the diverter switch insert and on the on-load tap-changer head.

![Same number of markings](image)

*Figure 66: Same number of markings*
3. **CAUTION!** Danger of lacerations when turning the coupling tube without an operating wrench. If the markings on the diverter switch insert are not aligned, turn the coupling tube so that the markings align, either by directly turning the shielding ring while wearing gloves or by using an operating wrench. Switch over the diverter switch insert if necessary.

![Figure 67: Markings on the diverter switch insert](image)

4. Attach lifting gear to diverter switch insert and position diverter switch insert over oil compartment.
5. Align the diverter switch insert such that the markings on the diverter switch insert and on the on-load tap-changer head align. Ensure that the protective ring is on the indicator drive shaft. Slowly lower diverter switch insert until it meets the oil compartment base. The shape of the selector coupling ensures that coupling is only possible in the correct position.

Figure 68: Markings on the diverter switch insert and the on-load tap-changer head
6. Check the distance between the upper rim edge of the adapter shaft on the diverter switch insert and the mounting surface of the on-load tap-changer head. The distance must be 13 ± 2 mm.

![Figure 69: Distance between the upper rim edge of the adapter shaft of the diverter switch insert and the mounting surface of the on-load tap-changer head](image)

5.2.6.2.3.2 Installing return pipe on VACUTAP VR®

**Installation for head version 1 and 2**

1. Secure holder bracket 4A with screw and hexagon nut (tightening torque 20 Nm).

![Figure 70: Return pipe for head version 1 and 2](image)

2. Insert return pipe in the bored hole of connection "S."
3. Place return pipe in holder bracket 4A.
4. Secure holder bracket B with washer and hexagon nut (tightening torque 20 Nm).
5. With tap-change supervisory control: Screw down holder bracket 4B with spacer bolt (tightening torque 14 Nm).
5 Mounting

Figure 71: Return pipe for head version 2 with tap-change supervisory control

1. On-load tap-changer head
2. Pipe connection S
3. Return pipe

4A Holder bracket
4B Spacer bolt

Figure 72: Return pipe for head version 3

1. On-load tap-changer head
2. Pipe connection S
3. Return pipe

4 Holder bracket
5 Holder plate

6. Secure plastic lug with hexagon nut (tightening torque 4 Nm).

**Installation of head version 3**

1. Insert return pipe in the bored hole of connection "S."
2. Place return pipe in holder bracket.
3. Secure holder bracket with washer and hexagon nut (tightening torque 20 Nm).
4. Secure holder plate with washers and hexagon nuts (tightening torque 20 Nm).
5. With tap-change supervisory control: Screw down tap-change supervisory control plate with washers and hexagon nuts (tightening torque 20 Nm).
5.2.6.2.3.3 Inserting the tap-change supervisory device

1. Insert mounting plate with tap-change supervisory device and drive shaft.
2. Check that drive shaft is seated correctly in the plug connector.

![Figure 75: Drive shaft and plug connector](image)

3. Attach mounting plate.

![Figure 76: Mounting plate](image)

4. Connect plug connector outside its bracket.

![Figure 77: Plug connector](image)
5. Insert plug connector into the bracket.

![Figure 78: Plug connector in bracket](image)

### 5.2.6.2.3.4 Inserting tap position indicator disk

Due to the coupling pin, the tap position indicator disk can only be installed when in the correct position.

► Place tap position indicator disk on indicator drive shaft, slide spring clip on to shaft end.

![Figure 79: Tap position indicator disk](image)
5.2.6.2.3.5  Securing on-load tap-changer head cover

**NOTICE**

Damage to the on-load tap-changer!

A missing or damaged o-ring as well as unclean sealing surfaces lead to insulating fluid escaping and therefore to damage to the on-load tap-changer.

► Ensure that the o-ring is positioned untwisted in the on-load tap-changer head cover.

► Ensure that the o-ring does not become damaged when mounting the cover.

► Ensure that the sealing surfaces on the on-load tap-changer head cover and on-load tap-changer head are clean.

1. Check that the feather key is securely positioned in the adapter shaft. Where necessary, use Vaseline to secure the feather key against falling out.

Figure 80: Feather key
2. Position the on-load tap-changer head cover on the on-load tap-changer head in such a way that the red triangular markings on the on-load tap-changer head and the on-load tap-changer head cover are aligned.

![On-load tap-changer head cover with o-ring](image)

Figure 81: On-load tap-changer head cover with o-ring

3. Screw the on-load tap-changer head cover onto the on-load tap-changer head.

![On-load tap-changer head cover](image)

Figure 82: On-load tap-changer head cover

### 5.2.6.2.4 Drying the on-load tap-changer

1. Connect pipe connections R and Q of on-load tap-changer head to the kerosene vapor lead using one shared lead.
2. Seal off unused pipe connections with a suitable blank cover.

![Diagram of transformer tank with a circular opening labeled Φ 50 mm](image)

Figure 83: Shared lead

**Vapor-phase drying in the transformer tank**

1. Supply kerosene vapor at a temperature of around 90°C. Keep this temperature constant for 3 to 4 hours.
2. Increase the kerosene vapor temperature by approx. 10°C/hour to the desired final temperature of max. 125°C at the on-load tap-changer.
3. Vacuum-dry on-load tap-changer at between 105°C and maximum 125°C for at least 50 hours.
4. Residual pressure of no more than $10^{-3}$ bar.

### 5.2.6.2.5 Closing kerosene drain plug

**NOTICE**

**Damage to the on-load tap-changer!**

Moisture in the oil compartment reduces the dielectric strength of the insulating fluid and thus leads to damage to the on-load tap-changer.

- Within 10 hours of drying, seal off oil compartment with on-load tap-changer head cover.

1. Remove [Section 5.2.6.2.1, Page 66] the diverter switch insert.
2. Close kerosene drain plug by turning clockwise with extended socket wrench (tightening torque 20 Nm).
3. Insert [Section 5.2.6.2.3, Page 74] the diverter switch insert.

If you wish to perform another transformer ratio test after drying, proceed as described in the section "Performing transformer ratio test following drying" [Section 5.2.8, Page 87].
5.2.7 Filling the oil compartment of the on-load tap-changer with insulating fluid

After drying, completely fill the oil compartment (divert switch insert fitted) with insulating fluid again as soon as possible so that an impermissible amount of humidity is not absorbed from the surroundings.

1. Establish a connecting lead between pipe connection E2 and one of the pipe connections R, S or Q to ensure equal pressure in the oil compartment and transformer during evacuation.

Figure 84: Connecting lead between E2 and Q

2. Fill on-load tap-changer with MIDEL 7131 using one of the two free pipe connections of the on-load tap-changer head.

Figure 85: Pipe connections S and R
5.2.8 Performing transformer ratio test after drying

**NOTICE**

Damage to the on-load tap-changer!

- Ensure that the selector / de-energized tap changer is fully immersed in the insulating fluid and that the oil compartment of the on-load tap-changer is completely filled with insulating fluid.
- Only switch the on-load tap-changer from one operating position to the next via the upper gear unit. You can use a short tube (diameter 25 mm) with screwed-in coupling bolt (diameter 12 mm) with a hand wheel or crank for this, for example. When using a drill, do not exceed a maximum speed of 250 rpm.
- Always check the operating position reached through the inspection window in the on-load tap-changer head cover. Never overshoot the end positions, which are indicated in the connection diagram supplied with the delivery.
- For multiple-column applications with a shared drive, link all on-load tap-changer heads to one another using the horizontal drive shaft part.

When actuating the change-over selector, a higher torque is required.

To perform the transformer ratio test, proceed as follows:
1. Switch the on-load tap-changer into the desired operating position. The diverter switch operation can be heard distinctly.
2. **NOTICE!** An incomplete tap-change operation may damage the on-load tap-changer. After operating the diverter switch, continue to crank the drive shaft of the upper gear unit for 2.5 revolutions in the same direction in order to correctly complete the tap-change operation.
3. Perform the transformer ratio test.
4. Repeat the transformer ratio test in all operating positions.
5. Once the transformer ratio test is complete, return on-load tap-changer to its adjustment position (see supplied connection diagram of the on-load tap-changer).

5.3 Installing on-load tap-changer in transformer (bell-type tank version)

The following chapters explain how to install the on-load tap-changer in the transformer.
5.3.1 Inserting on-load tap-changer into supporting structure

To insert the on-load tap-changer in the supporting structure, proceed as follows:

5.3.1.1 Securing selector on oil compartment

1. **CAUTION!** An unstably positioned selector may tip, resulting in injuries or property damage. Place the selector on a level surface and secure it against tipping.

2. Remove red-colored packaging material and transport material from the selector. Only remove the red protective cap on the 0-bar of the changeover selector after inserting the on-load tap-changer into the supporting structure.

3. Remove plastic bag with fastening materials from the selector and keep it ready.

Figure 86: Plastic bag with fastening materials
4. Remove the blocking strip from the selector coupling. Once the blocking strip is removed, the selector coupling may no longer be turned.

Figure 87: Selector coupling with blocking strip

5. **CAUTION!** An unstably positioned oil compartment may tip over, resulting in injuries or property damage. Place the oil compartment on a level surface and secure it against tipping.

Figure 88: Oil compartment
6. Remove the blocking strip from the coupling of the oil compartment base.

7. Lift the oil compartment by hooking up the on-load tap-changer head and carefully move it over the selector. The weight of the oil compartment is a maximum of 350 kg.

8. **NOTICE!** Lowering the oil compartment without due care can result in the oil compartment and selector colliding and becoming damaged. Carefully lower the oil compartment vertically, ensuring that the tap-selector connecting leads are free when lowering the oil compartment and do not touch the compartment.

9. Align the position of both coupling parts and attachment points on the oil compartment and the selector with one another. The correct position of the two coupling parts is shown in the adjustment plans supplied.
10. Screw selector onto oil compartment.

11. **NOTICE!** Incorrect tightening torques and unsecured screw connections can lead to damage to the on-load tap-changer. Screw the tap-selector connecting leads to connecting piece with care. Comply with the specified tightening torque, secure screw connections and snap the screening caps in place over the screw heads.
5.3.1.2 Inserting on-load tap-changer into supporting structure

1. **NOTICE!** Tensile forces can lead to damage and malfunctions on the on-load tap-changer. Using spacers, insert the on-load tap-changer vertically into the supporting structure (maximum 1° deviation from the vertical) so that the on-load tap-changer reaches its final installation height and only has to be raised a maximum of 5…20 mm once the tap winding and the on-load tap-changer take-off lead have been connected and the bell-type tank fitted.

![Figure 92: On-load tap-changer with spacers on supporting structure](image-url)
2. Temporarily fasten on-load tap-changer to supporting structure. The supporting flange has through holes for this purpose.

![Figure 93: Fastening the on-load tap-changer](image)

3. Remove the red protective cap on the 0-bar of the change-over selector.

![Figure 94: Protective cap](image)
5.3.2 Connecting the tap winding and on-load tap-changer take-off lead

**NOTICE**

**Damage to the on-load tap-changer!**

Connecting leads that place mechanical strain on the on-load tap-changer will damage the on-load tap-changer.

- Establish connections carefully.
- Do not twist connection contacts.
- Connect connecting leads without warping or deforming.
- If necessary, use an expansion loop for connecting leads.
- Fit screening caps provided to screw connections.

The tap winding and on-load tap-changer take-off lead must be connected in accordance with the connection diagram included with the delivery.

5.3.2.1 Tap selector connection contacts

The tap selector connection contacts are provided with a through-hole for M10 screws. The through-holes are either horizontal or vertical, depending on the on-load tap-changer model.

1. Fasten the tap-winding connecting leads to the tap selector in accordance with the connection diagram provided. The cable shoes and fastening materials are not included in the scope of delivery.

2. Take suitable measures to ensure that each fitting cannot come loose or settle (e.g. by using clamping washers). Be sure to attach the screening caps as shown in the illustration if these are included in the delivery scope.
3. Close the screening caps and make sure they are seated correctly. The screw head and nut must be fully covered.

**Figure 95: Tap selector connection contacts**

5.3.2.2 **Change-over selector connection contacts for reversing change-over selector connection**

**NOTICE**

**Damage to the on-load tap-changer!**

Tap-winding connecting leads situated too closely to the change-over selector's moving parts block the change-over selector and therefore result in damage to the on-load tap-changer.

- Tap-winding connecting leads in the area of the change-over selector have to be routed such that they are at a sufficient distance from the change-over selector's moving parts.

The (+) and (-) change-over selector connection contacts are designed as connecting lugs with through-holes for M10 screws for reversing change-over selector connection.

The connection contact K is designed as an extended tap selector connection contact with through-hole for M10 screws.

1. Fasten the tap-winding connecting leads to the change-over selector in accordance with the connection diagram provided. The cable shoes and fastening materials are not included in the scope of delivery.

2. Take suitable measures to ensure that each fitting cannot come loose or settle (e.g. by using clamping washers). Be sure to attach the screening caps if these are included in the delivery scope.
3. Close the screening caps and make sure they are seated correctly. The screw head and nut must be fully covered.

Figure 96: Change-over selector connection contacts for reversing change-over selector connection

Figure 97: Change-over selector connection contacts for reversing change-over selector connection (top view)
5.3.2.3 Change-over selector connection contacts for coarse tap selector connection

**NOTICE**

**Damage to the on-load tap-changer!**

Tap-winding connecting leads situated too closely to the change-over selector's moving parts block the change-over selector and therefore result in damage to the on-load tap-changer.

- Tap-winding connecting leads in the area of the change-over selector have to be routed such that they are at a sufficient distance from the change-over selector's moving parts.

With coarse tap selector connection, the external appearance of the (+) and (-) change-over selector connection contacts is identical to the tap selector contacts (through-hole for M10 screws, always in vertical position).

1. Fasten the tap-winding connecting leads to the change-over selector in accordance with the connection diagram provided. The cable shoes and fastening materials are not included in the scope of delivery.

2. Take suitable measures to ensure that each fitting cannot come loose or settle (e.g. by using clamping washers). Be sure to attach the screening caps if these are included in the delivery scope.

3. Close the screening caps and make sure they are seated correctly. The screw head and nut must be fully covered.

![Figure 98: Change-over selector connection contacts for coarse tap selector connection](image-url)
5.3.2.4 Connecting on-load tap-changer take-off lead

There are through-holes 13 mm in diameter at several points in the take-off ring of the oil compartment for connecting the on-load tap-changer take-off lead.

To connect the on-load tap-changer take-off lead, proceed as follows:

1. Connect the on-load tap-changer take-off lead to any through-hole on the take-off ring using the cable shoe and screw. The cable shoe and fastening materials are not included in the scope of delivery.
2. Take suitable measures to ensure the screw connection cannot come loose or settle (e.g. by using clamping washers).

![Figure 100: Take-off ring on oil compartment](image)

5.3.3 Performing transformer ratio test before drying

**NOTICE**

Damage to the on-load tap-changer!

Damage to the on-load tap-changer due to transformer ratio test being incorrectly performed.

- Do not perform more than 250 tap-change operations on the on-load tap-changer. If more than 250 tap-change operations are to be performed, completely fill the oil compartment with insulating fluid and lubricate sliding surfaces of contacts on the selector and selector gear with insulating fluid.

- Only switch the on-load tap-changer from one operating position to the next via the upper gear unit. You can use a short tube (diameter 25 mm) with screwed-in coupling bolt (diameter 12 mm) with a hand wheel or crank for this, for example. When using a drill, do not exceed a maximum speed of 250 rpm.

- Always check the operating position reached through the inspection window in the on-load tap-changer head cover. Never overshoot the end positions, which are indicated in the connection diagram supplied with the delivery.

- For multiple-column applications with a shared drive, link all on-load tap-changer heads to one another using the horizontal drive shaft parts.
When actuating the change-over selector, a higher torque is required.

To perform the transformer ratio test, proceed as follows:
1. Switch the on-load tap-changer into the desired operating position. The diverter switch operation can be heard distinctly.
2. **NOTICE!** An incomplete tap-change operation may damage the on-load tap-changer. After operating the diverter switch, continue to crank the drive shaft of the upper gear unit for 2.5 revolutions in the same direction in order to correctly complete the tap-change operation.
3. Perform the transformer ratio test.
4. Repeat the transformer ratio test in all operating positions.
5. Once the transformer ratio test is complete, return on-load tap-changer to its adjustment position (see supplied connection diagram of the on-load tap-changer).

After the transformer ratio test, open the kerosene drain plug in the oil compartment if the on-load tap-changer is to be dried with kerosene in the transformer tank. After drying, the diverter switch insert must be removed, the kerosene drain plug in the oil compartment closed and the diverter switch insert refitted.

### 5.3.4 Performing DC resistance measurement on transformer

Note the measurement scenarios listed below and the associated maximum measured currents when performing DC resistance measurement on the transformer.

The measured DC current is normally restricted to 10% of the rated current of the measured transformer winding in order to prevent the winding from overheating.

Perform the DC resistance measurement in various on-load tap-changer operating positions. You need to distinguish here whether the measured current is interrupted when changing operating position or not.

<table>
<thead>
<tr>
<th>Status of oil compartment</th>
<th>Without interruption in measured current</th>
<th>With interruption (measured current = 0 A before change in operating position)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil compartment empty</td>
<td>Maximum 10 A DC</td>
<td>Maximum 50 A DC</td>
</tr>
<tr>
<td>Oil compartment filled with insulating fluid</td>
<td>Maximum 50 A DC</td>
<td>Maximum 50 A DC</td>
</tr>
</tbody>
</table>

Table 5: Maximum permitted measured currents when performing DC resistance measurement on transformer
5.3.5 Drying on-load tap-changer in autoclave

**NOTICE**

**Damage to the on-load tap-changer!**

Moisture in the oil compartment reduces the dielectric strength of the insulating fluid and thus leads to damage to the on-load tap-changer.

► Within 10 hours of drying, seal off oil compartment with on-load tap-changer head cover.

Dry on-load tap-changer in accordance with the following instructions to ensure the dielectric values assured by MR for the on-load tap-changer.

If drying in an autoclave, the following methods are possible:

- Vacuum drying
- Vapor-phase drying

As an alternative to drying the on-load tap-changer in an autoclave, it can also be dried in the transformer tank.

5.3.5.1 Vacuum-drying in the autoclave

To vacuum-dry the on-load tap-changer in the autoclave, proceed as follows.

If you wish to perform another transformer ratio test after drying, proceed as described in the section "Performing transformer ratio test following drying" [► Section 5.3.10, Page 152].

5.3.5.1.1 Moving on-load tap-changer to adjustment position

► Move the on-load tap-changer into the adjustment position (see supplied connection diagram of the on-load tap-changer).

Figure 101: Adjustment position
5.3.5.1.2 Removing on-load tap-changer head cover

Danger of explosion!
Explosive gases under the on-load tap-changer head cover can deflagrate or explode and result in severe injury or death.

► Ensure that there are no ignition sources such as open flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.

► De-energize all auxiliary circuits (for example tap-change supervisory device, pressure relief device, pressure monitoring device) before removing the on-load tap-changer head cover.

► Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).

Damage to the on-load tap-changer!
Small parts in the oil compartment may block the diverter switch insert, thereby damaging the on-load tap-changer.

► Ensure that parts do not fall into the oil compartment.

► Check that all small parts are accounted for.

1. Ensure that the inspection window is sealed off with the cover.
2. Remove the screws and washers from the on-load tap-changer head cover.

Figure 102: On-load tap-changer head cover
3. Remove on-load tap-changer head cover.

![Figure 103: On-load tap-changer head cover](image)

### 5.3.5.1.3 Drying the on-load tap-changer

**NOTICE**

**Damage to the on-load tap-changer head cover and on-load tap-changer accessories.**

Both the on-load tap-changer head cover and the on-load tap-changer accessories will become damaged if they are dried in an autoclave.

- Keep the on-load tap-changer head cover and the following accessories outside the autoclave and never dry them with the on-load tap-changer: motor-drive unit, drive shaft, protective relay, pressure monitoring device, pressure relief device, bevel gear, temperature sensor, oil filter unit.

1. Heat up the on-load tap-changer in air at atmospheric pressure with a temperature increase of approximately 10°C/h to a final temperature of maximum 110°C.
2. Pre-dry the on-load tap-changer in circulating air at a maximum temperature of 110°C for a period of at least 20 hours.
3. Vacuum-dry on-load tap-changer at between 105°C and maximum 125°C for at least 50 hours.
4. Residual pressure of no more than 10⁻³ bar.

### 5.3.5.1.4 Securing on-load tap-changer head cover

**NOTICE**

**Damage to the on-load tap-changer!**

A missing or damaged o-ring as well as unclean sealing surfaces lead to insulating fluid escaping and therefore to damage to the on-load tap-changer.

- Ensure that the o-ring is positioned untwisted in the on-load tap-changer head cover.
- Ensure that the o-ring does not become damaged when mounting the cover.
- Ensure that the sealing surfaces on the on-load tap-changer head cover and on-load tap-changer head are clean.
1. Check that the feather key is securely positioned in the adapter shaft. Where necessary, use Vaseline to secure the feather key against falling out.

![Figure 104: Feather key](image1)

2. Position the on-load tap-changer head cover on the on-load tap-changer head in such a way that the red triangular markings on the on-load tap-changer head and the on-load tap-changer head cover are aligned.

![Figure 105: On-load tap-changer head cover with o-ring](image2)
3. Screw the on-load tap-changer head cover onto the on-load tap-changer head.

![Figure 106: On-load tap-changer head cover](image)

### 5.3.5.2 Vapor-phase drying in the autoclave

To dry the on-load tap-changer with kerosene in the autoclave, proceed as follows.

If you wish to perform another transformer ratio test after drying, proceed as described in the section "Performing transformer ratio test following drying" [Section 5.3.10, Page 152].

![Figure 107: Adjustment position](image)

### 5.3.5.2.1 Moving on-load tap-changer to adjustment position

Move the on-load tap-changer into the adjustment position (see supplied connection diagram of the on-load tap-changer).
5.3.5.2.2 Removing on-load tap-changer head cover

**Danger of explosion!**

Explosive gases under the on-load tap-changer head cover can deflagrate or explode and result in severe injury or death.

- Ensure that there are no ignition sources such as open flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.
- De-energize all auxiliary circuits (for example tap-change supervisory device, pressure relief device, pressure monitoring device) before removing the on-load tap-changer head cover.
- Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).

**Notice**

**Damage to the on-load tap-changer!**

Small parts in the oil compartment may block the diverter switch insert, thereby damaging the on-load tap-changer.

- Ensure that parts do not fall into the oil compartment.
- Check that all small parts are accounted for.

1. Ensure that the inspection window is sealed off with the cover.
2. Remove the screws and washers from the on-load tap-changer head cover.

![Figure 108: On-load tap-changer head cover](image)
3. Remove on-load tap-changer head cover.

![Figure 109: On-load tap-changer head cover](image)

### 5.3.5.2.3 Opening kerosene drain plug

> **NOTICE!** Unscrew kerosene drain plug between oil compartment base and selector gear clockwise until it starts to offer resistance to turning. Never unscrew the kerosene drain plug all the way.

![Figure 110: Kerosene drain plug](image)

### 5.3.5.2.4 Drying the on-load tap-changer

**NOTICE**

**Damage to the on-load tap-changer head cover and on-load tap-changer accessories.**

Both the on-load tap-changer head cover and the on-load tap-changer accessories will become damaged if they are dried in an autoclave.

> Keep the on-load tap-changer head cover and the following accessories outside the autoclave and never dry them with the on-load tap-changer: motor-drive unit, drive shaft, protective relay, pressure monitoring device, pressure relief device, bevel gear, temperature sensor, oil filter unit.
5 Mounting

1. Supply kerosene vapor at a temperature of around 90°C. Keep this temperature constant for 3 to 4 hours.
2. Increase the kerosene vapor temperature by approx. 10°C/hour to the desired final temperature of max. 125°C at the on-load tap-changer.
3. Vacuum-dry on-load tap-changer at between 105°C and maximum 125°C for at least 50 hours.
4. Residual pressure of no more than 10⁻³ bar.

5.3.5.2.5 Closing kerosene drain plug

► NOTICE! An open kerosene drain plug leads to insulating fluid escaping from the oil compartment and therefore to damage to the on-load tap-changer. Close kerosene drain plug (tightening torque 20 Nm).

5.3.5.2.6 Securing on-load tap-changer head cover

NOTICE

Damage to the on-load tap-changer!

A missing or damaged o-ring as well as unclean sealing surfaces lead to insulating fluid escaping and therefore to damage to the on-load tap-changer.

► Ensure that the o-ring is positioned untwisted in the on-load tap-changer head cover.
► Ensure that the o-ring does not become damaged when mounting the cover.
► Ensure that the sealing surfaces on the on-load tap-changer head cover and on-load tap-changer head are clean.

1. Check that the feather key is securely positioned in the adapter shaft. Where necessary, use Vaseline to secure the feather key against falling out.

![Figure 111: Feather key](image-url)
2. Position the on-load tap-changer head cover on the on-load tap-changer head in such a way that the red triangular markings on the on-load tap-changer head and the on-load tap-changer head cover are aligned.

![Figure 112: On-load tap-changer head cover with o-ring](image)

3. Screw the on-load tap-changer head cover onto the on-load tap-changer head.

![Figure 113: On-load tap-changer head cover](image)
5.3.6 Lifting top part of on-load tap-changer head off supporting flange (bottom part)

5.3.6.1 Removing on-load tap-changer head cover

**WARNING**
Explosive gases under the on-load tap-changer head cover can deflagrate or explode and result in severe injury or death.

► Ensure that there are no ignition sources such as open flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.

► De-energize all auxiliary circuits (for example tap-change supervisory device, pressure relief device, pressure monitoring device) before removing the on-load tap-changer head cover.

► Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).

**NOTICE**
Damage to the on-load tap-changer!
Small parts in the oil compartment may block the diverter switch insert, thereby damaging the on-load tap-changer.

► Ensure that parts do not fall into the oil compartment.

► Check that all small parts are accounted for.

1. Ensure that the inspection window is sealed off with the cover.
2. Remove temporary fastening and spacers and slowly lower the on-load tap-changer.

Figure 114: Temporary fasteners and spacers
3. Remove the screws and washers from the on-load tap-changer head cover.

Figure 115: On-load tap-changer head cover

4. Remove on-load tap-changer head cover.

Figure 116: On-load tap-changer head cover

5.3.6.2 Removing tap position indicator disk

Pull spring clip off shaft end and remove tap position indicator disk.

Figure 117: Tap position indicator disk
5.3.6.3 Removing the tap-change supervisory device

**DANGER**

**Electric shock!**

If supply voltage is applied to the tap-change supervisory device, this can result in electric shock.

> Disconnect the tap-change supervisory device from the supply voltage and secure it to prevent it from being switched back on again.

**NOTICE**

**Damage to the tap-change supervisory device!**

Removing the tap-change supervisory device without due care may damage the tap-change supervisory device, thereby resulting in damage to the on-load tap-changer.

> Remove the tap-change supervisory device with care in order not to damage or rip out the connecting leads.

1. Take the tap-change supervisory device plug connector out of the mounting bracket and disconnect it.

![Figure 118: Plug connector](image)

2. Remove nuts and locking elements on the mounting plate.

![Figure 119: Mounting plate](image)
3. Remove mounting plate with tap-change supervisory device and drive shaft.

Figure 120: Mounting plate with tap-change supervisory device and drive shaft

4. Lift the lead of the tap-change supervisory device off the spacer bolt.

Figure 121: Spacer bolt and lead of the tap-change supervisory device
5. Swivel lead of the tap-change supervisory device out of the on-load tap-changer head.

Figure 122: Lead of tap-change supervisory device

6. Remove spacer bolt with locking element.

Figure 123: Spacer bolt

5.3.6.4 Removing return pipe on VACUTAP VR®

Removal for head version 1 and 2

1. Remove both hexagon nuts from the studs on the holder brackets.
5 Mounting

Figure 124: Return pipe for head version 1 and 2

1. On-load tap-changer head
2. Pipe connection S
3. Return pipe
4. Mounting bracket

For version with tap-change supervisory control: also unscrew spacer bolts (if present).

Figure 125: Return pipe for head version 2 with tap-change supervisory control

1. On-load tap-changer head
2. Pipe connection S
3. Return pipe
4. Mounting bracket
5. Spacer bolt

3. Remove the washers and holder brackets in succession.
4. Pull return pipe out of hole.

Removal for head version 3

1. Remove hexagon nuts from studs of holder brackets and plates (retaining plate or tap-change supervisory control plate).
2. Remove washers, plate and holder brackets in succession.
3. Pull return pipe out of hole.
5.3.6.5 Lifting top part of on-load tap-changer head off supporting flange

1. Remove nuts and locking elements between top part of on-load tap-changer head and supporting flange.

2. Lift top part of on-load tap-changer head off supporting flange.

5.3.7 Attaching the bell-type tank and connecting the on-load tap-changer to the top part of the on-load tap-changer head

The following chapters explain how to connect the on-load tap-changer to the top part of the on-load tap-changer head once the bell-type tank has been attached.
5.3.7.1 Attaching bell-type tank

1. Clean sealing surface of supporting flange, place o-ring on supporting flange.

   ![Supporting flange with o-ring](image1)

   Figure 130: Supporting flange with o-ring

2. Lift the bell-type tank over the active part of the transformer.

   ![Bell-type tank](image2)

   Figure 131: Bell-type tank
5.3.7.2 Positioning top part of on-load tap-changer head on bell-type tank

1. **NOTICE!** Unsuitable gaskets lead to insulating fluid escaping and therefore to damage to the on-load tap-changer. Place a gasket suitable for the insulating fluid used and the application on the mounting flange. Clean the sealing surfaces on the mounting flange and on-load tap-changer head.

![Figure 132: Mounting flange with gasket](image-url)
2. Lower and position the top part of the on-load tap-changer head on mounting flange so that the triangular markings, pins and mounting holes on the top part and bottom part of the on-load tap-changer head are aligned.

5.3.7.3 Connecting on-load tap-changer to top part of on-load tap-changer head

**NOTICE**

Incorrectly lifting the on-load tap-changer will damage it!

If the connection screws of the supporting flange are used to lift the on-load tap-changer, the screws may be damaged, which makes it impossible to properly screw the on-load tap-changer and the on-load tap-changer head together!

► Always lift the on-load tap-changer with the specified lifting traverse, and never with the connection screws of the supporting flange.
5 Mounting

1. Carefully insert lifting device into the oil compartment with claws turned in.

![Image of lifting device](Figure 134: Lifting device)

2. **NOTICE!** Inaccurate alignment of on-load tap-changer head to supporting flange will damage the on-load tap-changer when it is lifted. Swing claws of lifting device outwards, use lifting device to lift oil compartment. Ensure that the triangular markings are aligned and that all supporting flange stud bolts go easily through the mounting holes of the on-load tap-changer head.

![Image of lifting on-load tap-changer](Figure 135: Lifting on-load tap-changer)

When fitting the top part and bottom part of the on-load tap-changer head together, leave the pins for the mounting plate of the tap-change supervisory device, the pins for the mounting bracket of the oil suction pipe and the spacer bolts for the lead of the tap-change supervisory device free.
1. Screw top part of on-load tap-changer head to bottom part using nuts and locking elements.

Figure 136: Screwing the top part of the on-load tap-changer head to the bottom part

2. Remove the lifting device with the claws turned in.

Figure 137: Removing lifting device

3. Screw the on-load tap-changer head to the mounting flange.

Figure 138: Screwing the on-load tap-changer head to the mounting flange
5.3.7.4 Installing return pipe on VACUTAP VR®

Installation for head version 1 and 2

1. Secure holder bracket 4A with screw and hexagon nut (tightening torque 20 Nm).

![Figure 139: Return pipe for head version 1 and 2](image)

2. Insert return pipe in the bored hole of connection "S."

3. Place return pipe in holder bracket 4A.

4. Secure holder bracket B with washer and hexagon nut (tightening torque 20 Nm).

5. With tap-change supervisory control: Screw down holder bracket 4B with spacer bolt (tightening torque 14 Nm).

![Figure 140: Return pipe for head version 2 with tap-change supervisory control](image)

6. Secure plastic lug with hexagon nut (tightening torque 4 Nm).
Installation of head version 3

1. Insert return pipe in the bored hole of connection "S."
2. Place return pipe in holder bracket.
3. Secure holder bracket with washer and hexagon nut (tightening torque 20 Nm).
4. Secure holder plate with washers and hexagon nuts (tightening torque 20 Nm).

5. With tap-change supervisory control: Screw down tap-change supervisory control plate with washers and hexagon nuts (tightening torque 20 Nm).

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5 Mounting

5.3.7.5 Inserting the tap-change supervisory device

1. Insert mounting plate with tap-change supervisory device and drive shaft.

Figure 143: Mounting plate with tap-change supervisory device and drive shaft

2. Check that drive shaft is seated correctly in the plug connector.

Figure 144: Drive shaft and plug connector
3. Attach mounting plate.

4. Attach spacer bolt for fastening the lead of the tap-change supervisory device.

5. Fasten lead of tap-change supervisory device to spacer bolt.
5 Mounting

6. Connect plug connector outside its bracket.

![Figure 148: Plug connector](image)

7. Insert plug connector into the bracket.

![Figure 149: Plug connector in bracket](image)

5.3.7.6 Inserting tap position indicator disk

Due to the coupling pin, the tap position indicator disk can only be installed when in the correct position.
5 Mounting

► Place tap position indicator disk on indicator drive shaft, slide spring clip on to shaft end.

![Figure 150: Tap position indicator disk](image)

5.3.7.7 Securing on-load tap-changer head cover

**NOTICE**

**Damage to the on-load tap-changer!**

A missing or damaged o-ring as well as unclean sealing surfaces lead to insulating fluid escaping and therefore to damage to the on-load tap-changer.

► Ensure that the o-ring is positioned untwisted in the on-load tap-changer head cover.

► Ensure that the o-ring does not become damaged when mounting the cover.

► Ensure that the sealing surfaces on the on-load tap-changer head cover and on-load tap-changer head are clean.

1. Check that the feather key is securely positioned in the adapter shaft. Where necessary, use Vaseline to secure the feather key against falling out.

![Figure 151: Feather key](image)
2. Position the on-load tap-changer head cover on the on-load tap-changer head in such a way that the red triangular markings on the on-load tap-changer head and the on-load tap-changer head cover are aligned.

![Figure 152: On-load tap-changer head cover with o-ring](image)

3. Screw the on-load tap-changer head cover onto the on-load tap-changer head.

![Figure 153: On-load tap-changer head cover](image)

5.3.8 Drying on-load tap-changer in transformer tank

Dry on-load tap-changer in accordance with the following instructions to ensure the dielectric values assured by MR on the on-load tap-changer.

If you want to dry the on-load tap-changer in the transformer tank, fully assemble the transformer first and then undertake drying.
If drying in the transformer tank, the following methods are possible:

- Vacuum-drying
- Vapor-phase drying

As an alternative to drying the on-load tap-changer in the transformer tank, it can also be dried in an autoclave.

### 5.3.8.1 Vacuum-drying in the transformer tank

To vacuum-dry the on-load tap-changer in the transformer tank, proceed as follows.

The on-load tap-changer head cover remains closed during the entire drying process.

1. Establish a connecting lead either between connections E2 and Q or connections E2 and R on the on-load tap-changer head.
2. Seal off unused pipe connections with a suitable blank cover.

**Figure 154: Connecting lead**

**Vacuum-drying in the transformer tank**

1. Heat up the on-load tap-changer in air at atmospheric pressure with a temperature increase of approximately 10°C/h to a final temperature of maximum 110°C.
2. Pre-dry the on-load tap-changer in circulating air at a maximum temperature of 110°C for a period of at least 20 hours.
3. Vacuum-dry on-load tap-changer at between 105°C and maximum 125°C for at least 50 hours.
4. Residual pressure of no more than $10^{-3}$ bar.

If you wish to perform another transformer ratio test after drying, proceed as described in the section "Performing transformer ratio test following drying" [Section 5.3.10, Page 152].
5.3.8.2 Vapor-phase drying in the transformer tank

If you have not opened the kerosene drain plug in advance (e.g. after the transformer ratio test), you have to open the kerosene drain plug before the vapor-phase drying process so that the kerosene condensate can drain from the oil compartment.

The kerosene drain plug is located in the oil compartment base and is not accessible with the diverter switch insert installed and the transformer tank closed. For this reason, you first have to remove the diverter switch insert, open the kerosene drain plug, and then install the diverter switch insert again. After the drying process, you have to remove the diverter switch insert again to close the kerosene drain plug.

5.3.8.2.1 Removing diverter switch insert

To remove the diverter switch insert, proceed as follows.

5.3.8.2.1.1 Moving on-load tap-changer to adjustment position

► Move the on-load tap-changer into the adjustment position (see supplied connection diagram of the on-load tap-changer).

![Figure 155: Adjustment position](image)

5.3.8.2.1.2 Removing on-load tap-changer head cover

**Danger of explosion!**

Explosive gases under the on-load tap-changer head cover can deflagrate or explode and result in severe injury or death.

► Ensure that there are no ignition sources such as open flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.

► De-energize all auxiliary circuits (for example tap-change supervisory device, pressure relief device, pressure monitoring device) before removing the on-load tap-changer head cover.

► Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).
NOTICE

Damage to the on-load tap-changer!
Small parts in the oil compartment may block the diverter switch insert, thereby damaging the on-load tap-changer.

► Ensure that parts do not fall into the oil compartment.
► Check that all small parts are accounted for.

1. Ensure that the inspection window is sealed off with the cover.
2. Remove the screws and washers from the on-load tap-changer head cover.

![Figure 156: On-load tap-changer head cover](image1)

3. Remove on-load tap-changer head cover.

![Figure 157: On-load tap-changer head cover](image2)
5.3.8.2.1.3 Removing tap position indicator disk

Pull spring clip off shaft end and remove tap position indicator disk.

![Image of tap position indicator disk]

Figure 158: Tap position indicator disk

5.3.8.2.1.4 Removing the tap-change supervisory device

**NOTICE**

Damage to the tap-change supervisory device!

Removing the tap-change supervisory device without due care may damage the tap-change supervisory device, thereby resulting in damage to the on-load tap-changer.

Remove the tap-change supervisory device with care in order not to damage or rip out the connecting leads.

1. Take the tap-change supervisory device plug connector out of the mounting bracket and disconnect it.

![Image of plug connector]

Figure 159: Plug connector
2. Remove nuts and locking elements on the mounting plate.

3. Remove mounting plate with tap-change supervisory device and drive shaft.
4. Swivel lead of the tap-change supervisory device out of the on-load tap-changer head in the direction of the arrow.

![Figure 162: Lead of tap-change supervisory device](image)

5.3.8.2.1.5 Removing return pipe on VACUTAP VR®

**Removal for head version 1 and 2**

1. Remove both hexagon nuts from the studs on the holder brackets.

![Figure 163: Return pipe for head version 1 and 2](image)

<table>
<thead>
<tr>
<th>1</th>
<th>On-load tap-changer head</th>
<th>3</th>
<th>Return pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Pipe connection S</td>
<td>4A</td>
<td>Mounting bracket</td>
</tr>
<tr>
<td></td>
<td>4B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. For version with tap-change supervisory control: also unscrew spacer bolts (if present).
3. Remove the washers and holder brackets in succession.
4. Pull return pipe out of hole.

**Removal for head version 3**

1. Remove hexagon nuts from studs of holder brackets and plates (retaining plate or tap-change supervisory control plate).
5 Mounting

5.3.8.2.1.6 Lifting out diverter switch insert

1. **CAUTION!** Danger of lacerations when turning the coupling tube without an operating wrench. If the markings on the coupling flange and on-load tap-changer head are not aligned, turn the coupling tube so that the markings align, either by directly turning the shielding ring while wearing gloves or by using an operating wrench.

2. Insert the lifting gear in the eyebolts of the coupling tube and position vertically above the diverter switch insert.
3. Lift the diverter switch insert slowly and vertically out of oil compartment, ensuring that the protective ring on the indicator drive shaft does not become detached when doing so.

![Figure 168: Diverter switch insert](image)

4. **CAUTION!** An unstably positioned diverter switch insert may tip, resulting in injuries or property damage. Place the diverter switch insert on a level surface and secure it against tipping. Do not operate the diverter switch insert or change the position of the selector coupling when the diverter switch insert is not installed.

![Figure 169: Diverter switch insert](image)
5.3.8.2 Opening kerosene drain plug

**NOTICE!** Unscrew kerosene drain plug with extended socket wrench counter-clockwise until it starts to offer resistance to turning. Never unscrew the kerosene drain plug all the way.

![Figure 170: Kerosene drain plug](image)

5.3.8.2.3 Inserting diverter switch insert

Proceed as follows to fit the diverter switch insert.

5.3.8.2.3.1 Inserting diverter switch insert

1. To fit the diverter switch insert, ensure that the selector coupling is in the adjustment position.

![Figure 171: Adjustment markings in oil compartment base](image)
2. **NOTICE!** Damage to the on-load tap-changer by mixing up the diverter switch inserts. Ensure that there are the same the number of markings on the diverter switch insert and on the on-load tap-changer head.

Figure 172: Same number of markings
3. **CAUTION!** Danger of lacerations when turning the coupling tube without an operating wrench. If the markings on the diverter switch insert are not aligned, turn the coupling tube so that the markings align, either by directly turning the shielding ring while wearing gloves or by using an operating wrench. Switch over the diverter switch insert if necessary.

![Figure 173: Markings on the diverter switch insert](image)

4. Attach lifting gear to diverter switch insert and position diverter switch insert over oil compartment.
5. Align the diverter switch insert such that the markings on the diverter switch insert and on the on-load tap-changer head align. Ensure that the protective ring is on the indicator drive shaft. Slowly lower diverter switch insert until it meets the oil compartment base. The shape of the selector coupling ensures that coupling is only possible in the correct position.

Figure 174: Markings on the diverter switch insert and the on-load tap-changer head
6. Check the distance between the upper rim edge of the adapter shaft on
the diverter switch insert and the mounting surface of the on-load tap-
changer head. The distance must be $13 \pm 2$ mm.

![Figure 175: Distance between the upper rim edge of the adapter shaft of the diverter switch insert and the mounting surface of the on-load tap-changer head](image)

5.3.8.2.3.2 Installing return pipe on VACUTAP VR®

Installation for head version 1 and 2

1. Secure holder bracket 4A with screw and hexagon nut (tightening torque 20 Nm).

![Figure 176: Return pipe for head version 1 and 2](image)

<p>| | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>On-load tap-changer head</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Pipe connection $S$</td>
<td>4A</td>
</tr>
</tbody>
</table>

2. Insert return pipe in the bored hole of connection "$S$".

3. Place return pipe in holder bracket 4A.

4. Secure holder bracket B with washer and hexagon nut (tightening torque 20 Nm).

5. With tap-change supervisory control: Screw down holder bracket 4B with spacer bolt (tightening torque 14 Nm).
6. Secure plastic lug with hexagon nut (tightening torque 4 Nm).

### Installation of head version 3

1. Insert return pipe in the bored hole of connection "S."
2. Place return pipe in holder bracket.
3. Secure holder bracket with washer and hexagon nut (tightening torque 20 Nm).
4. Secure holder plate with washers and hexagon nuts (tightening torque 20 Nm).
5. With tap-change supervisory control: Screw down tap-change supervisory control plate with washers and hexagon nuts (tightening torque 20 Nm).
5.3.8.2.3.3 Inserting the tap-change supervisory device

1. Insert mounting plate with tap-change supervisory device and drive shaft.
2. Check that drive shaft is seated correctly in the plug connector.

Figure 181: Drive shaft and plug connector

3. Attach mounting plate.

Figure 182: Mounting plate

4. Connect plug connector outside its bracket.

Figure 183: Plug connector
5. Insert plug connector into the bracket.

**Figure 184: Plug connector in bracket**

### 5.3.8.2.3.4 Inserting tap position indicator disk

Due to the coupling pin, the tap position indicator disk can only be installed when in the correct position.

► Place tap position indicator disk on indicator drive shaft, slide spring clip on to shaft end.

**Figure 185: Tap position indicator disk**
Securing on-load tap-changer head cover

**NOTICE**

Damage to the on-load tap-changer!

A missing or damaged o-ring as well as unclean sealing surfaces lead to insulating fluid escaping and therefore to damage to the on-load tap-changer.

► Ensure that the o-ring is positioned untwisted in the on-load tap-changer head cover.

► Ensure that the o-ring does not become damaged when mounting the cover.

► Ensure that the sealing surfaces on the on-load tap-changer head cover and on-load tap-changer head are clean.

1. Check that the feather key is securely positioned in the adapter shaft. Where necessary, use Vaseline to secure the feather key against falling out.

![Figure 186: Feather key](image-url)
2. Position the on-load tap-changer head cover on the on-load tap-changer head in such a way that the red triangular markings on the on-load tap-changer head and the on-load tap-changer head cover are aligned.

![On-load tap-changer head cover with o-ring](image1)

3. Screw the on-load tap-changer head cover onto the on-load tap-changer head.

![On-load tap-changer head cover](image2)

**5.3.8.2.4 Drying the on-load tap-changer**

1. Connect pipe connections R and Q of on-load tap-changer head to the kerosene vapor lead using one shared lead.
2. Seal off unused pipe connections with a suitable blank cover.

![Diagram](image)

**Figure 189: Shared lead**

#### Vapor-phase drying in the transformer tank

1. Supply kerosene vapor at a temperature of around 90°C. Keep this temperature constant for 3 to 4 hours.
2. Increase the kerosene vapor temperature by approx. 10°C/hour to the desired final temperature of max. 125°C at the on-load tap-changer.
3. Vacuum-dry on-load tap-changer at between 105°C and maximum 125°C for at least 50 hours.
4. Residual pressure of no more than $10^{-3}$ bar.

#### 5.3.8.2.5 Closing kerosene drain plug

**NOTICE**

**Damage to the on-load tap-changer!**

Moisture in the oil compartment reduces the dielectric strength of the insulating fluid and thus leads to damage to the on-load tap-changer.

► Within 10 hours of drying, seal off oil compartment with on-load tap-changer head cover.

1. Remove [► Section 5.3.8.2.1, Page 131] the diverter switch insert.
2. Close kerosene drain plug by turning clockwise with extended socket wrench (tightening torque 20 Nm).
3. Insert [► Section 5.3.8.2.3, Page 139] the diverter switch insert.

If you wish to perform another transformer ratio test after drying, proceed as described in the section "Performing transformer ratio test following drying" [► Section 5.3.10, Page 152].
5.3.9 Filling the oil compartment of the on-load tap-changer with insulating fluid

After drying, completely fill the oil compartment (diverter switch insert fitted) with insulating fluid again as soon as possible so that an impermissible amount of humidity is not absorbed from the surroundings.

1. Establish a connecting lead between pipe connection E2 and one of the pipe connections R, S or Q to ensure equal pressure in the oil compartment and transformer during evacuation.

![Figure 190: Connecting lead between E2 and Q](image)

2. Fill on-load tap-changer with MIDEL 7131 using one of the two free pipe connections of the on-load tap-changer head.

![Figure 191: Pipe connections S and R](image)
5.3.10 Performing transformer ratio test after drying

**NOTICE**

Damage to the on-load tap-changer!

Damage to the on-load tap-changer due to transformer ratio test being incorrectly performed.

- Ensure that the selector / de-energized tap changer is fully immersed in the insulating fluid and that the oil compartment of the on-load tap-changer is completely filled with insulating fluid.

- Only switch the on-load tap-changer from one operating position to the next via the upper gear unit. You can use a short tube (diameter 25 mm) with screwed-in coupling bolt (diameter 12 mm) with a hand wheel or crank for this, for example. When using a drill, do not exceed a maximum speed of 250 rpm.

- Always check the operating position reached through the inspection window in the on-load tap-changer head cover. Never overshoot the end positions, which are indicated in the connection diagram supplied with the delivery.

- For multiple-column applications with a shared drive, link all on-load tap-changer heads to one another using the horizontal drive shaft part.

To perform the transformer ratio test, proceed as follows:

1. Switch the on-load tap-changer into the desired operating position. The diverter switch operation can be heard distinctly.

2. **NOTICE!** An incomplete tap-change operation may damage the on-load tap-changer. After operating the diverter switch, continue to crank the drive shaft of the upper gear unit for 2.5 revolutions in the same direction in order to correctly complete the tap-change operation.

3. Perform the transformer ratio test.

4. Repeat the transformer ratio test in all operating positions.

5. Once the transformer ratio test is complete, return on-load tap-changer to its adjustment position (see supplied connection diagram of the on-load tap-changer).
5.4 Fitting protective devices and drive components

5.4.1 Connecting the tap-change supervisory device

**DANGER**
Risk of fatal injury due to electrical voltage!
Danger of death due to electrical voltage when assembling and connecting the device.

► De-energize the device and system peripherals and lock them to prevent them from being switched back on.

► Connect monitoring contacts integrated into the on-load tap-changer head (terminal box on pipe connection Q) to the motor-drive unit terminals using a connecting lead as specified in the connection diagram provided.

5.4.2 Electrically connecting temperature sensors

Size the cable for the electrical connection of the temperature sensors such that you can turn the sensors if necessary when mounting the drive shaft.

1. Electrically connect the temperature sensors in accordance with the connection diagram provided.
2. Loop the temperature sensors into the tripping circuit of the circuit breaker via the temperature monitoring relay in accordance with the connection diagram supplied such that the transformer is immediately de-energized by the circuit breaker when the temperature of the insulating fluid in the oil compartment reaches 140°C.

5.4.3 Installing protective relay in piping and connecting

**WARNING**
Danger of explosion!
Explosive gases in the protective relay can deflagrate or explode and result in severe injury or death.

► Wait 15 minutes after switching off the transformer before beginning further work on the protective relay so that the gases can dissipate.

► Ensure that there are no ignition sources such as naked flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.

► De-energize all auxiliary circuits before beginning work.

► Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).

Always perform all transformer tests with the protective relay attached and connected.
5.4.3.1 Checking function of protective relay

Check the function of the protective relay before installing it in piping between on-load tap-changer head and oil conservator. The associated contact positions for checking electrical continuity are shown in the dimensional drawing provided.

1. Loosen the three screws on the terminal box cover and lift off the terminal box cover.

![Terminal box cover](image)

2. Remove the slotted head screw for potential tie-in and remove the terminal box cover with wire.

![Terminal box cover](image)

**NOTICE**

**Damage to protective relay!**

Damage to protective relay resulting from improper operation.

► Never press both test buttons at the same time.
5 Mounting

3. Press OFF test button.
   ⇒ Flap valve is inclined. Line marker appears in the middle of the inspection window.

![Figure 194: OFF position](image1)

4. Press OPERATION test button.
   ⇒ Flap valve is vertical.

![Figure 195: OPERATION position](image2)
5. Position the wire for the terminal box cover and affix using the slotted head screw.

![Figure 196: Terminal box cover](image)

6. Attach the terminal box cover and secure with screws.

![Figure 197: Terminal box cover](image)

### 5.4.3.2 Installing protective relay in piping

Ensure the following for installation and proper function of the protective relay:

1. Install protective relay such that it can be easily accessed for subsequent maintenance work.
2. Install protective relay with good support and free from vibrations.
3. The test buttons must be at the top.
4. The pipes from the protective relay to the oil conservator must be routed with an inclination of at least 2% to ensure the switching gases can escape freely.

5. The inner piping diameter must be at least 25 mm.

6. The magnetic field strength (bushings, busbars etc.) must be < 20 kA/m. Higher field strengths have a negative effect on the function of the protective relay.

Figure 198: Pipe
7. The reference arrow on the terminal box cover must point toward the on-load tap-changer's oil conservator.

Figure 199: Reference arrow pointing towards the on-load tap-changer's oil conservator
8. Install the protective relay horizontally in the pipe between on-load tap-changer head and oil conservator as near as possible to the on-load tap-changer head.

Figure 200: Protective relay horizontal and with test button at the top
9. Install a stop-cock (nominal width of at least 25 mm) between protective relay and oil conservator.

![Figure 201: Stop-cock](image)

### 5.4.3.3 Making the electrical connections for the protective relay

The protective relay's dry-reed magnetic switching tubes are supplied in the standard version as either NC or NO contacts. Other contact combinations can be supplied as special versions and are shown in the dimensional drawing provided.

**WARNING**

Danger of death or severe injury!

Risk of death or severe injury due to improper electrical connection of the protective relay.

- Loop the protective relay into the tripping circuit of the circuit breakers of the transformer to be protected so that the transformer is immediately de-energized by the circuit breakers when the protective relay is tripped.
- Systems which only generate an alarm message are not permitted.
1. Insert cable gland in the tapped hole with the most favorable position.

![Tapped hole](image)

Figure 202: Tapped hole

2. Seal open tapped hole with dummy plug.

![Sealed with dummy plug](image)

Figure 203: Sealed with dummy plug

3. Loosen the three screws on the terminal box cover and lift off the terminal box cover.

![Terminal box cover](image)

Figure 204: Terminal box cover
4. Remove the slotted head screw for potential tie-in and remove the terminal box cover with wire.

Figure 205: Terminal box cover

5. Remove screw for the protective cover and take off the protective cover.

Figure 206: Protective cover

6. Guide cable through cable gland and into protective relay. Ensure that the cable gland is well connected and sealed.

Figure 207: Cable bushing
5 Mounting

7. Connect the electric cables to the connection terminals in accordance with the connection diagram on the dimensional drawing.

Figure 208: Electrical cables

8. Connect protective conductor to cylinder head screw.

Figure 209: Protective conductor

9. Insert the protective cover and secure using the screw.

Figure 210: Protective cover
10. Position the wire for the terminal box cover and affix using the slotted head screw.

![Figure 211: Terminal box cover](image)

11. Attach the terminal box cover and secure with screws.

![Figure 212: Terminal box cover](image)

5.4.4 Fitting motor-drive unit

- Fit motor-drive unit to transformer as described in relevant MR operating instructions for motor-drive unit.

5.4.5 Fitting drive shaft

Observe the following during mounting:

**Resistance to corrosion of components**

The square tubes, coupling brackets, coupling bolts, screws, and locking washers are corrosion-resistant. We therefore recommend not applying the same external coating to these parts as to the transformer tank.
Cutting square tubes, telescopic protective tubes, and protective cover

The square tubes, the telescopic protective tube and the protective cover are supplied over-length (graded standard lengths). You must cut these parts to the required size before mounting on the transformer. In rare cases, you also have to cut the inner tube of the telescopic protective tube to the desired length. The maximum permitted total drive shaft length of the drive - last column = 15 m.

<table>
<thead>
<tr>
<th>Standard lengths</th>
<th>Motor-drive unit</th>
<th>Manual drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>600</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>900</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>1300</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>1700</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>2000</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>2500</td>
<td>Not permitted</td>
<td>•(^{1)}</td>
</tr>
</tbody>
</table>

\(^{1)} \geq 2000 only possible for vertical installation without shaft protection! Telescopic protective tubes for manual drives with vertical dimensions V1 > 2462 are to be supplied with vertical intermediate bearing, as with the motor-drive unit.

Table 6: Graded standard lengths of square tubes
5.4.5.1 Fitting a vertical drive shaft without cardan joint

Permitted axial displacement

Minor axial displacement of the vertical drive shaft is permitted as long as it does not exceed 35 mm per 1000 mm of square tube length (this corresponds to 2°).

![Diagram showing permitted maximum axial displacement of vertical drive shaft without cardan joint](image)

To fit the vertical drive shaft to the drive, proceed as follows:

1. **CAUTION!** Switch off motor protective switch Q1 in the motor-drive unit (position O). If this is not done, the motor-drive unit may be started inadvertently and cause injuries.
5 Mounting

2. Fasten the bevel gear to the transformer.

Figure 214: Bevel gear
3. Determine dimension A between shaft end of drive and shaft end of bevel gear. Shorten square tube to length of A – 9 mm.

Figure 215: Shortening square tube
4. Deburr cut surfaces of square tube.

Figure 216: Deburring cut surfaces
5. Slide the loosely screwed together coupling part onto square tube until stop is reached.

Figure 217: Slide coupling part onto square tube
6. Insert coupling bolt into shaft end of drive. Greasing coupling part, Slide square tube with coupling part onto shaft end.

Figure 218: Sliding square tube with coupling part onto shaft end

7. Attach square tube to drive.

Figure 219: Attaching square tube to drive
8. Pivot square tube away from axis.

![Figure 220: Pivoting square tube away from axis](image)

9. When installing inner tube of telescopic protective tube, shorten on the side without slots if necessary. The minimum dimension for the overlap of the two protective tubes is 100 mm.
Inner tube must not be deformed and must be deburred in order to slide easily in the outer tube.

**Figure 221: Deburring inner tube**

<table>
<thead>
<tr>
<th>Dimension A (= distance between shaft end of drive and shaft end of bevel gear)</th>
<th>Inner tube</th>
<th>Outer tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>170 mm...190 mm</td>
<td>Shorten to 200 mm</td>
<td>= 200 mm</td>
</tr>
<tr>
<td>191 mm...1130 mm</td>
<td>Dimension A + 20 mm</td>
<td>= 200 mm</td>
</tr>
<tr>
<td>1131 mm...1598 mm</td>
<td>= 700 mm</td>
<td>= 1150 mm</td>
</tr>
<tr>
<td>1599 mm...2009 mm</td>
<td>= 1150 mm</td>
<td>= 1150 mm</td>
</tr>
</tbody>
</table>
10. Slide outer tube over inner tube. When doing so, make sure that the non-slotted side of the inner tube is facing upwards. Slide telescopic protective tube onto square tube. Then slide hose clips over telescopic protective tube.

Figure 222: Sliding on telescopic protective tube
11. Place adapter ring over bearing collar of bevel gear and slide upwards. Insert coupling bolt into shaft end of bevel gear. Pivot square tube back to axis.

Figure 223: Fitting adapter ring and coupling bolt
12. Grease coupling brackets, coupling bolt and shaft end (e.g. ISOFLEX TOPAS L32) and secure square tube with coupling brackets on the bevel gear. Set a unilateral axial clearance of 3 mm between coupling bolt and upper coupling piece.

![Figure 224: Mounting coupling brackets](image)

13. Attach bottom protective tube (inner tube) with a hose clip to bearing collar of drive. Then slide upper protective tube (outer tube) over adapter ring on bevel gear. Secure upper protective tube to bottom protective tube with hose clip both at top end and at the connection point.
Figure 225: Mounting protective tube
5.4.5.2 Fitting a horizontal drive shaft without cardan joints

Permitted axial displacement

Minor axial displacement of the horizontal drive shaft is permitted as long as it does not exceed 35 mm per 1000 mm of square tube length (this corresponds to 2°).

![Permitted maximum axial displacement of horizontal drive shaft without cardan joint](image)

Aligning upper gear unit on the on-load tap-changer head

In order to correctly install the horizontal drive shaft, under certain circumstances you may have to first align the upper gear unit such that the horizontal drive shaft is flush with the shaft end of the upper gear unit.

To do so, proceed as follows:

1. **NOTICE!** Damage to the on-load tap-changer due to alignment of the gear unit when the oil compartment is not completely full. Ensure that the oil compartment is filled completely with insulating fluid.
2. Loosen screws and turn pressure ring segments to one side.

Figure 227: Pressure ring segments

3. **NOTICE!** Align gear unit such that the horizontal drive shaft is flush with the drive shaft of the gear unit. While aligning the gear unit, turn the unit's drive shaft such that its output shaft retains its original position. Failure to do so may result in damage to the de-energized tap-changer and transformer when starting up.

Figure 228: Aligning gear unit
4. Swivel pressure ring segments back towards gear unit and tighten screws. Ensure that the spring washer is between the screw head and pressure ring segment and that the pressure ring segments are firmly in contact with the gear unit housing.

![Figure 229: Securing pressure ring segments](image)

**Fitting horizontal drive shaft**

You can turn the temperature sensor if this is necessary for fitting the drive shaft.

To fit the horizontal drive shaft, proceed as follows.

1. Calculate dimension A between shaft end of upper gear unit and shaft end of bevel gear and shorten square tube to length A–9 mm.

![Figure 230: Shortening square tube](image)
2. Calculate inside width B between housings of upper gear unit and bevel gear. Cut down the protective cover to B-2 mm and deburr the cut edges. Protect protective cover against corrosion with a coat of paint.

Figure 231: Shortening, deburring, and coating protective cover
3. Slide loosely screwed together coupling part onto square tube until stop is reached.

Figure 232: Sliding coupling part onto square tube
4. Grease coupling bolt, coupling part and shaft end of the bevel gear (e.g. ISOFLEX TOPAS L32) and insert coupling bolt into shaft end. Thread hose clip onto square tube and slide square tube with coupling part onto shaft end.

Figure 233: Slide square tube with coupling part onto shaft end

5. Secure square tube on bevel gear.

Figure 234: Securing square tube on bevel gear
6. Grease coupling bolt, coupling brackets and shaft end of the upper gear unit (e.g. ISOFLEX TOPAS L32) and insert coupling bolt into shaft end. Secure square tube with coupling brackets on upper gear unit.

Figure 235: Secure square tube on upper gear unit.
7. Attach shortened protective cover to housing lugs on the on-load tap-changer head and bevel gear. Secure each end of protective cover with a hose clip.

Figure 236: Fitting protective cover
8. If using a bearing block or angle gear, attach caps to the protective cover.

Figure 237: Bearing block caps

Figure 238: Angle gear caps
5.4.5.3 Fitting the vertical drive shaft with cardan joints

You can fit the vertical drive shaft with cardan joints onto the motor-drive unit and bevel gear.

**Permitted axial displacement**

An axial displacement of maximum 20° to the side facing away from the transformer is permitted for the vertical drive shaft with cardan joints. An axial displacement of maximum 2° to the side facing the transformer is permitted.

![Permitted maximum axial displacement of vertical drive shaft with cardan joints](image)

**NOTICE**

Damage to property!

Improper mounting of the cardan joint may result in damage or malfunctions.

- Ensure that the folding cardan joint does not damage the expansion bellows during mounting.
- Ensure that the angle of deflection α to the side facing away from the transformer is not greater than 20°.
- Ensure that the angle of deflection α to the side facing the transformer is not greater than 2°.
- Ensure that the angle of deflection α is the same on both cardan joints.
Figure 240: Angle of deflection $\alpha$
To fit the drive shaft with cardan joints, proceed as follows:

1. Grease coupling bolts, coupling brackets, and shaft ends, e.g. ISOFLEX TOPAS L 32.

Figure 241: Greasing coupling bolts, coupling brackets, and shaft ends
2. Insert adapter rings into the collar of the rotating protective tube 1. Fit the two parts of pivotable protective tube together 2 and turn them towards one another 3 to set the corresponding angle.

Figure 242: Inserting adapter in pivotable protective tubes
3. When supplied, the cardan joints are fitted with coupling bolts 1. To mount on the shaft end, the following steps must be taken: Remove hose clip 2. Slide up expansion bellows 3. Remove coupling bolt 4. Slide cardan joint over device’s output shaft 5. Push in coupling bolt 6. Slide expansion bellows over this 7. Secure expansion bellows with hose clip 8.

4. Connect shorter cardan joint supplied to shaft end of motor-drive unit with coupling bolt.
5. **NOTICE!** Attach second, longer cardan joint to the bevel gear such that the position of both cardan joint lugs is the same on the bevel gear and motor-drive unit. If this is not done, damage or malfunctions may result.

![Figure 245: Fitting second cardan joint on bevel gear](image)


![Figure 246: Securing expansion bellows with hose clip](image)
5 Mounting

7. Provisionally connect loose shaft ends of the joints to an angle bar and align so that they are in line.

Figure 247: Connecting shaft ends with angle bar
8. Determine dimension A between the shaft ends. Cut square tube to LR = A + 106 mm (LR = length of square tube). Deburr cut surfaces of square tube.

Figure 248: Shortening square tube
9. Before mounting, shorten both telescopic tubes to dimension $A/2 + 120$ mm ($A =$ dimension between both cardan joint ends) and deburr.

Figure 249: Shortening telescopic tubes
10. Fit one adapter ring to bearing collar of motor-drive unit and fit other adapter ring to bearing collar of bevel gear.

Figure 250: Fitting adapters

11. Slide previously shortened and deburred square tube over upper cardan joint end until stop is reached.

Figure 251: Sliding square tube over upper cardan joint end
5 Mounting

12. Thread upper flexible protective tube with long outlet up onto square tube from below.

Figure 252: Sliding flexible protective tube over square tube
13. Slide inner tube into outer tube such that the slotted sides of the outer and inner tube are both facing down. Thread the hose clips.

Figure 253: Sliding on telescopic tubes
14. Slide everything up and secure with a screw clamp.

Figure 254: Secure everything with a screw clamp
15. Slide bottom flexible protective tube (also with long outlet up) on to the square tube and secure with screw clamp.

Figure 255: Sliding bottom flexible protective tube onto square tube
16. Swing in square tube and slide all the way down.

Figure 256: Swinging square tube in
17. Tighten bottom coupling brackets. Shaft end and coupling part must be securely connected such that no axial clearance remains between the coupling bolt and coupling bracket.
18. Fit upper coupling brackets with 3 mm axial clearance.

19. Working from top to bottom, mount the individual parts of the shaft protection. Set angle position between both parts of pivotable protective tube and fix with available hose clip. Secure both upper and lower protective tubes with a hose clip at both ends. Secure the two telescopic protective tubes to one another using a hose clip.

The plastic adapters must be at the respective end of the pivotable protective tube. Only slide telescopic protective tube into upper and lower pivotable protective tubes by the width of the adapter before tightening the hose clips.
5.4.5.4 Fitting drive shaft with insulator

A model with insulator in the vertical drive shaft is available for insulating installation of the drive shaft.
5 Mounting

Permitted axial displacement

Minor axial displacement of the vertical drive shaft with insulator is permitted as long as it does not exceed 35 mm per 1000 mm square tube length (that corresponds to 2°).

![Diagram showing permitted maximum axial displacement of vertical drive shaft with insulator]

Figure 260: Permitted maximum axial displacement of vertical drive shaft with insulator

5.4.5.4.1 Fitting vertical drive shaft with insulator

To fit the vertical drive shaft, proceed as follows.

1. **CAUTION!** Switch off motor protective switch Q1 in the motor-drive unit (position O). If this is not done, the motor-drive unit may be started inadvertently and cause injuries.
2. Screw down the bevel gear for fastening on the transformer on both sides with the contact washers provided to ensure permanent grounding. Screws are not included in the scope of supply.

Figure 261: Bevel gear
3. Determine dimension A between shaft end of drive and shaft end of bevel gear. Shorten square tube to length of A–179 mm taking the insulator into account.

Figure 262: Shortening square tube
4. Deburr cut surfaces of square tube.

Figure 263: Deburring cut surfaces

5. Screw down double coupling part with insulator supplied and square tube. Mount insulator on the side facing the drive.

Figure 264: Screwing down square tube and insulator with double coupling part
6. Slide loosely screwed together coupling part onto insulator until stop is reached.

Figure 265: Sliding coupling part onto insulator

7. Place the supplied insulator ring on the bearing collar of the motor-drive unit.

Figure 266: Insulating ring

8. Insert coupling bolt into shaft end of drive. Grease coupling part, coupling bolt and shaft end (e.g. ISOFLEX TOPAS L32). Slide square tube with coupling part onto shaft end.

Figure 267: Sliding square tube with coupling part onto shaft end
5 Mounting

9. Attach square tube to drive.

![Figure 268: Attaching square tube to drive](image)

10. Pivot square tube away from axis.

![Figure 269: Pivoting square tube away from axis](image)

11. When installing inner tube of telescopic protective tube, shorten on the side without slots if necessary. The minimum dimension for the overlap of the two protective tubes is 100 mm.
Inner tube must not be deformed and must be deburred in order to slide easily in the outer tube.

Figure 270: Deburring inner tube

<table>
<thead>
<tr>
<th>Dimension A (= distance between shaft end of drive and shaft end of bevel gear)</th>
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</table>
12. Slide outer tube over inner tube. When doing so, make sure that the non-slotted side of the inner tube is facing upwards. Slide telescopic protective tube onto square tube. Then slide hose clips over telescopic protective tube.

Figure 271: Sliding on telescopic protective tube
13. Place adapter ring over bearing collar of bevel gear and slide upwards. Insert coupling bolt into shaft end of bevel gear. Pivot square tube back to axis.

Figure 272: Fitting adapter ring and coupling bolt
14. Grease coupling brackets, coupling bolt and shaft end (e.g. ISOFLEX TOPAS L32) and secure square tube with coupling brackets on the bevel gear. Set a unilateral axial clearance of 3 mm between coupling bolt and upper coupling piece.

Figure 273: Mounting coupling brackets

15. Attach bottom protective tube (inner tube) with a hose clip to bearing collar of drive 1. Then slide upper protective tube (outer tube) over adapter on bevel gear 2. Secure upper protective tube to bottom protective tube with hose clip both at top end and at the connection point 3.
5.4.5.5 Fitting drive shaft with insulator and cardan joint

A model with insulator and cardan joint in the vertical drive shaft is also available for insulating installation of the drive shaft.
Permitted axial displacement

An axial displacement of maximum 20° to the side facing away from the transformer is permitted for the vertical drive shaft with cardan joints and insulator. An axial displacement of maximum 2° to the side facing the transformer is permitted.

Figure 275: Permitted maximum axial displacement of vertical drive shaft with insulator and cardan joint

5.4.6 Centering on-load tap-changer and motor-drive unit

Center on-load tap-changer and motor-drive unit as described in relevant MR operating instructions for motor-drive unit.

5.4.7 Making the electrical connections for the motor-drive unit

Make electrical connections for the motor-drive unit as described in relevant MR operating instructions for motor-drive unit.
6 Commissioning

**Danger of explosion!**
Explosive gases in the oil compartment of the on-load tap-changer, transformer, pipework system, oil conservator and at the dehydrating breather opening can deflagrate or explode and result in severe injury or death!

► Ensure that there are no ignition sources such as naked flame, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the transformer's immediate surroundings during commissioning and that none occur.

► Do not operate any electrical devices (e.g. risk of sparks from impact wrench).

► Only use conductive and grounded hoses, pipes, and pump equipment that are approved for flammable liquids.

**Danger of explosion!**
Overloading the on-load tap-changer can lead to explosion and, due to spraying hot oil and flying parts, to death and serious injuries. Property damage is highly probable.

► Ensure that the on-load tap-changer is not overloaded.

► Ensure use of the on-load tap-changer in accordance with section "Appropriate use".

► Prevent operations outside of the permitted operating conditions by taking suitable measures.

This chapter describes how to commission the on-load tap-changer.

### 6.1 Commissioning the on-load tap-changer at the transformer manufacturer's site

Perform the following work and functional checks before commissioning the transformer.

#### 6.1.1 Bleeding on-load tap-changer head and pipe system
Prior to commissioning, you must bleed the on-load tap-changer head and the pipe system.

#### 6.1.1.1 Bleeding on-load tap-changer head
1. Open all forward valves and return valves in the pipe system.
2. Remove screw cap on air-vent valve E1 on the on-load tap-changer head cover.

![Figure 276: Screw cap](image)

3. Use screwdriver to lift valve tappet on air-vent valve E1 and bleed on-load tap-changer head.

![Figure 277: Valve tappet](image)

4. Seal air-vent valve E1 with screw cap (tightening torque 10 Nm).
6.1.1.2 **Bleeding the pipe system**

1. Remove the screw caps on the pipe bends on pipe connections A and S.

![Figure 278: Screw cap](image)

2. Open the vent screw and bleed the pipe system.
3. Close the vent screw and seal with the screw caps.
4. Bleed the pipe system at other points at which the option of bleeding has been provided. More information can be found in the operating instructions for the oil cooling unit.

6.1.2 **Grounding the on-load tap-changer**

1. Connect grounding screw on the on-load tap-changer head to transformer cover. It is essential that CUPAL washers are placed directly on the connecting lug on both sides. The aluminum side of the CUPAL washers must be facing the connecting lug.

![Figure 279: Ground connection on the on-load tap-changer head](image)
2. Connect the grounding screw on the motor-drive unit to the transformer tank. It is essential that a CUPAL washer is placed between the cable shoe and connecting lug. The aluminum side of the CUPAL washer must be facing the connecting lug.

Figure 280: Ground connection on the motor-drive unit

3. Connect the grounding screw on the motor-drive unit to the shielding housing.

Figure 281: Ground connection on the motor-drive unit and shielding housing
4. Connect the housing of the temperature sensors to the grounding screw on the on-load tap-changer head or to another grounding point on the transformer. It is essential that a CUPAL washer is placed between the cable shoe and temperature sensor housing. The aluminum side of the CUPAL washer must be facing the temperature sensor housing.

![Figure 282: Grounding the temperature sensors](image)

6.1.3 Checking motor-drive unit

**NOTICE**

**Damage to the on-load tap-changer / de-energized tap-changer!**

Damage to the on-load tap-changer / de-energized tap-changer due to activation of the on-load tap-changer / de-energized tap-changer without insulating fluid.

- Ensure that the selector / de-energized tap changer is fully immersed in insulating fluid and that the oil compartment of the on-load tap-changer is completely filled with insulating fluid.

Prior to commissioning the transformer, check whether the motor-drive unit and on-load tap-changer are correctly coupled and that the motor-drive unit functions correctly.

**Tests on the motor-drive unit**

1. Perform function checks as described in relevant MR operating instructions for motor-drive unit.

2. **NOTICE!** An incorrectly coupled motor-drive unit will lead to damage to the on-load tap-changer. Undertake trial tap-change operations across the entire range of settings. Ensure that in each operating position, the tap position indicators of motor-drive unit and on-load tap-changer (inspection window in the on-load tap-changer head) match.

**Dielectric tests on transformer wiring**

- Note information relating to dielectric tests on transformer wiring in relevant MR operating instructions for motor-drive unit.
6.1.4 High-voltage tests on the transformer

Note the following points before performing high voltage tests on the transformer:

▪ Ensure that the temperature of the insulating fluid both in the oil compartment and in the transformer does not exceed 60°C during the high-voltage test.

▪ Ensure that the oil compartment of the on-load tap-changer is completely filled with insulating fluid.

▪ Ensure that all protective devices for the on-load tap-changer are functioning correctly and are ready for use.

▪ Ensure that the ground connections on the motor-drive protective housing and protective housing fastening are free of paint.

▪ Only perform high voltage test if motor-drive unit door is closed.

▪ Disconnect external connections to electronic components in the motor-drive unit to prevent damage from overvoltage.

▪ When connecting the motor-drive unit's supply voltage, only use the cable bushings in the protective housing base intended for lead insertion.

▪ Guide all ground connecting leads to one central connection point (establishment of suitable reference earth).

▪ Disconnect all electronic components before the high voltage test. Before a dielectric test of the wiring, remove all devices with a withstand voltage of < 1000 V.

▪ Remove leads used for testing before the high voltage test as these function as antennas.

▪ Wherever possible, route the measurement leads and data leads separately to the energy cables.

Contact the manufacturer if you have any questions about possible sources of danger.

6.2 Transporting transformer to the operating site

**NOTICE**

Damage to motor-drive unit!

Damage to the motor-drive unit due to condensate in protective housing of motor-drive unit.

► Always keep protective housing of the motor-drive unit tightly closed.

► In the event of downtime lasting more than 8 weeks prior to initial commissioning, connect and operate the anti-condensation heater in the motor-drive unit. If this is not possible, place a sufficient amount of desiccant in the protective housing.
6.2.1 Transport with drive removed

If the drive must be removed in order to transport the transformer, proceed as follows:

1. Ensure that the drive and the on-load tap-changer are in the adjustment position.
2. Remove the drive.
3. Do not actuate the drive while the on-load tap-changer is uncoupled and do not turn the output shaft.
4. Do not actuate an on-load tap-changer which is uncoupled and do not turn its drive shaft.
5. Transport the drive to the installation site in the MR delivery packaging.
6. Fit drive [Section 5.4.4, Page 164] and drive shaft [Section 5.4.5, Page 164] to transformer at the installation site.

6.2.2 Transport with full transformer tank and without oil conservator

When storing or transporting the transformer with a full transformer tank but without an oil conservator, a connecting lead must be installed between the interior of the oil compartment and the transformer tank’s oil chamber for pressure compensation.

To do so, proceed as follows:

► Establish connecting lead on the on-load tap-changer head between connections E2 and Q or E2 and R.

![Connecting lead](image)

In the event of a short-term immobilization time (maximum of 4 weeks) without an oil conservator, it is also sufficient to remove approximately 5 liters of insulating fluid from the on-load tap-changer oil compartment.
6.2.3 Transport with empty transformer tank

NOTICE

Damage to the on-load tap-changer!

The on-load tap-changer may be subject to oscillating movements during transformer transportation if the transformer is transported without insulating fluid and the on-load tap-changer oil compartment is transported with insulating fluid. These oscillating movements can lead to damage to the on-load tap-changer.

► Completely empty the oil compartment if the transformer is to be transported without insulating fluid.

► Preserve the oil compartment in the same way as the transformer (for example by filling with N2).

To empty the oil compartment, proceed as follows:

6.2.3.1 Emptying the oil compartment and oil conservator

1. Ensure that the stop-cock between oil conservator and on-load tap-changer is open.
2. Remove the screw cap on air-vent valve E1 on the on-load tap-changer head cover.
3. Use a screwdriver to lift the valve tappet on air-vent valve E1.
   ⇢ The gas under the on-load tap-changer head cover escapes. When doing so, ensure sufficient ventilation.
4. Once the gas has been discharged and insulating fluid is flowing out of the air-vent valve, close the air-vent valve.
5. Close the stop-cock between the oil conservator and on-load tap-changer.
6. Open the air-vent valve E1 again and drain off the insulating fluid until the area under the on-load tap-changer head cover is unoccupied.
7. Remove the screws and washers from the on-load tap-changer head cover.

Figure 284: On-load tap-changer head cover
8. Remove on-load tap-changer head cover.

9. Suck the insulating fluid out of the oil compartment.

10. Open the stop-cock between oil conservator and on-load tap-changer.

   ⇒ The insulating fluid flows out of the oil conservator into the oil compartment.

11. Suck the insulating fluid out of the oil compartment.

### 6.3 Commissioning transformer at operating site

Before energizing the transformer, check that the motor-drive unit and protective devices are functioning correctly and fill the on-load tap-changer oil compartment with fresh insulating fluid. To do so, proceed as follows:

#### 6.3.1 Filling the oil compartment of the on-load tap-changer with insulating fluid

1. **NOTICE!** Check whether the on-load tap-changer head cover has a flange for attaching a pressure relief device. If it does, operation without a pressure relief device is not permitted and may result in damage to the on-load tap-changer.

   ⇒ Fit a pressure relief device which is approved for this on-load tap-changer on the on-load tap-changer head.
2. Establish a connecting lead between pipe connection E2 and one of the pipe connections R, S or Q to ensure equal pressure in the oil compartment and transformer during evacuation.

![Figure 286: Connecting lead between E2 and Q](image)

3. Fill on-load tap-changer with fresh Midel 7131 using one of the two free pipe connections on the on-load tap-changer head.

![Figure 287: Pipe connections S and R](image)

4. Remove sample from the oil compartment.
5. Record the temperature of the sample immediately after the sample is taken.
6. Determine dielectric strength and water content at a sample temperature of 20°C ± 5°C. The dielectric strength and water content must comply with the limit values specified in the technical data.
6.3.2 Bleeding on-load tap-changer head and pipe system

Prior to commissioning, you must bleed the on-load tap-changer head and the pipe system.

6.3.2.1 Bleeding on-load tap-changer head

1. Open all forward valves and return valves in the pipe system.
2. Remove screw cap on air-vent valve E1 on the on-load tap-changer head cover.

3. Use screwdriver to lift valve tappet on air-vent valve E1 and bleed on-load tap-changer head.

4. Seal air-vent valve E1 with screw cap (tightening torque 10 Nm).
6.3.2.2 Bleeding the pipe system

1. Remove the screw caps on the pipe bends on pipe connections A and S.

2. Open the vent screw and bleed the pipe system.

3. Close the vent screw and seal with the screw caps.

4. Bleed the pipe system at other points at which the option of bleeding has been provided. More information can be found in the operating instructions for the oil cooling unit.

6.3.3 Checking motor-drive unit

**NOTICE**

Damage to the on-load tap-changer / de-energized tap-changer!

Damage to the on-load tap-changer / de-energized tap-changer due to actuation of the on-load tap-changer / de-energized tap-changer without insulating fluid.

- Ensure that the selector / de-energized tap changer is fully immersed in insulating fluid and that the oil compartment of the on-load tap-changer is completely filled with insulating fluid.
**NOTICE**

Damage to the on-load tap-changer and motor-drive unit!

Damage to on-load tap-changer and motor-drive unit due to incorrect use of position transmitter equipment.

- Only circuits stated in the chapter Technical data for position transmitter equipment may be connected to the position transmitter module connections.

- The switchover point of the position transmitter equipment in the motor-drive unit is not the same as the switchover point of the diverter switch operation. This depends on the type of diverter switch. This fact should be noted when project planning the locking circuits between the motor-drive unit and external equipment (e.g. transformer circuit breaker).

- Therefore, the “Tap changer in operation” position transit contact shown in the connection diagram should be used for external monitoring, locking and control purposes instead of the position transmitter equipment.

Prior to commissioning the transformer, check whether the motor-drive unit and on-load tap-changer are correctly coupled and that the motor-drive unit functions correctly.

**Tests on the motor-drive unit**

1. Perform function checks as described in relevant MR operating instructions for motor-drive unit.

2. **NOTICE!** An incorrectly coupled motor-drive unit will lead to damage to the on-load tap-changer. Undertake trial tap-change operations across the entire range of settings. Ensure that in each operating position, the tap position indicators of motor-drive unit and on-load tap-changer (inspection window in the on-load tap-changer head) match.

**Dielectric tests on transformer wiring**

- Note information relating to dielectric tests on transformer wiring in relevant MR operating instructions for motor-drive unit.


- Check that the protective relay is functioning correctly before commissioning the transformer:
  1. Ground the transformer on the high-voltage side and low-voltage side. Ensure that the grounding for work connection on the transformer is not removed during testing.
  2. Ensure that the transformer remains de-energized during testing.
  3. Deactivate the automatic fire extinguishing device.
  4. Loosen the three screws on the terminal box cover and lift off the terminal box cover.
5. Remove the slotted head screw for potential tie-in and remove the terminal box cover with wire.
6. Press OFF test button.
7. Leave the transformer's danger zone.
8. Ensure that the transformer's circuit breaker cannot be closed.
   ✷ Passive protection test
9. Press OPERATION test button.
10. Leave the transformer's danger zone.
11. Close the transformer's circuit breaker with isolating switches open and the transformer grounded on all sides.
12. Press OFF test button.
13. Ensure that the transformer's circuit breaker is open.
   ✷ Active protection test.
14. Press OPERATION test button to reset the protective relay.
15. Position the wire for the terminal box cover and affix using the slotted head screw.
16. Attach the terminal box cover and secure with screws.

6.3.5 Commissioning the transformer

- Oil cooling unit is mounted and ready for operation.
- Temperature sensors are connected and looped into the tripping circuit of the circuit breaker.
- The signaling contact for falling below the minimum oil level in the on-load tap-changer's oil conservator is looped into the tripping circuit of the circuit breaker.
- The protective relay and additional protective devices are looped into the circuit breaker's tripping circuit.
- The motor-drive unit and all protective devices are functioning correctly and are ready for use.
- The oil compartment of the on-load tap-changer is completely filled with insulation fluid.
- All stop-cocks between on-load tap-changer and oil conservator of the on-load tap-changer are open.

1. Switch on transformer.
2. **NOTICE!** Inrush current impulses can be significantly greater than the transformer rated current and may lead to current paths with asymmetrical or non-sinusoidal curve shapes and, as a result, overload the on-load tap-changer during the diverter switch operation. Only perform tap-change operations - whether under no load or under load conditions - once the in-rush current impulse has subsided.
7 Fault elimination

**WARNING**

**Danger of explosion!**

Explosive gases under the on-load tap-changer head cover can deflagrate or explode and result in severe injury or death.

- Ensure that there are no ignition sources such as open flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.
- De-energize all auxiliary circuits (for example tap-change supervisory device, pressure relief device, pressure monitoring device) before removing the on-load tap-changer head cover.
- Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).

**NOTICE**

**Damage to the on-load tap-changer and transformer!**

If the protective relay or other protective devices trip, this can indicate damage to the on-load tap-changer and transformer. The transformer must not be energized without being inspected first.

- Check on-load tap-changer and transformer when protective relay or other protective devices have been tripped.
- Do not use the equipment again until you are sure there is no damage to the on-load tap-changer or transformer.

**NOTICE**

**Damage to motor-drive unit!**

Damage to the motor-drive unit due to condensate in protective housing of motor-drive unit.

- Always keep protective housing of the motor-drive unit tightly closed.
- In the event of operation interruptions of more than 2 weeks, connect and operate the anti-condensation heater in the motor-drive unit. If this is not possible, e.g. during transportation, place a sufficient amount of desiccant in the protective housing.

The table below is intended to assist with detecting and, where possible, remediating faults.

For more information, please consult the operating instructions for the RS protective relay or the relevant protective device.

In the event of faults on the on-load tap-changer or motor-drive unit which cannot be easily corrected on site, or if the RS protective relay or additional protective devices have been tripped, please inform your authorized MR representative, the transformer manufacturer or contact us directly at:

Maschinenfabrik Reinhausen GmbH
Technical Service
Postfach 12 03 60
93025 Regensburg
<table>
<thead>
<tr>
<th>Fault description</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripping of protective relay (e.g. RS)</td>
<td>See section &quot;Tripping the protective relay and re-commissioning the transformer [► Section 7.1, Page 234]&quot; Also contact MR.</td>
</tr>
<tr>
<td>Activation of tap-change supervisory device</td>
<td>The motor-drive unit can no longer be electrically actuated once the tap-change supervisory device has been activated. Manual operation of the motor-drive unit via the hand crank when the transformer is switched on is prohibited. On-load tap-changer and transformer must be checked. Depending on the cause of tripping, take measurements / carry out checks on the transformer. Contact MR to check the on-load tap-changer.</td>
</tr>
<tr>
<td>Activation of rupture disk in on-load tap-changer head cover</td>
<td>On-load tap-changer and transformer must be checked. Depending on the cause of tripping, take measurements / carry out checks on the transformer. Contact MR to check the on-load tap-changer.</td>
</tr>
<tr>
<td>Tripping of motor protective switch Q1 in motor-drive unit</td>
<td>See chapter &quot;Fault elimination&quot; in the operating instructions of the TAPMOTION® ED motor-drive unit</td>
</tr>
<tr>
<td>Tripping of signaling contact that indicates that the fill level has fallen below the minimum in the on-load tap-changer oil conservator</td>
<td>Check pipe system (pipes etc.) and on-load tap-changer head for leaks. Check the fill level and the quality of the insulating fluid in accordance with the operating instructions for the on-load tap-changer. If the fill level has fallen below the limit values, also contact MR.</td>
</tr>
<tr>
<td>On-load tap-changer not changing tap position (sluggishness, Raise keys / Lower keys not working, no audible diverter switch action)</td>
<td>Contact MR.</td>
</tr>
<tr>
<td>No change in voltage on transformer despite change in position on motor-drive unit</td>
<td>Contact MR.</td>
</tr>
<tr>
<td>Tap position indicator on motor-drive unit and on-load tap-changer different</td>
<td>Contact MR.</td>
</tr>
<tr>
<td>Noises on drive shaft or motor-drive unit when changing tap position</td>
<td>Ensure proper mounting of the drive shaft in accordance with its operating instructions. Check that hose clips and protective covers are seated correctly. Contact MR in the event of noise from the motor-drive unit.</td>
</tr>
<tr>
<td>Red message on monitoring unit</td>
<td>If possible read out database and send to MR along with error code.</td>
</tr>
<tr>
<td>Warning or tripping of Buchholz relay on transformer</td>
<td>Notify manufacturer of transformer.</td>
</tr>
<tr>
<td>Deviation from desired value when measuring winding resistance of transformer</td>
<td>Contact manufacturer of transformer and, if necessary, MR, and provide measured values.</td>
</tr>
<tr>
<td>Deviation from desired value during dissolved gas analysis (transformer oil)</td>
<td>Contact manufacturer of transformer and, if necessary, MR, and provide measured values.</td>
</tr>
</tbody>
</table>
### Fault elimination

<table>
<thead>
<tr>
<th>Fault description</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviation from desired value during transformer ratio test</td>
<td>Contact manufacturer of transformer and, if necessary, MR, and provide measured values.</td>
</tr>
<tr>
<td>Deviation from limit value for diverter switch oil values</td>
<td>Carry out oil change, check oil conservator breather of on-load tap-changer.</td>
</tr>
</tbody>
</table>
| On-load tap-changer switches to static operation and message "Status B7, B8, B9" (K43) | • Contact MR  
• Reduce temperature of the insulating fluid in the oil compartment to <120°C* until fault elimination  
• One-time static emergency operation up to an insulating fluid temperature of 140°C* in the oil compartment permissible for a maximum of 48 hours |
| On-load tap-changer switches to static operation and message "OLTC Oil Temperature >120°C" (K44) and oil cooling pump runs (K7/Q4) | • Check fan and eliminate fault  
• If the fan is OK: Contact MR  
• Reduce temperature of the insulating fluid in the oil compartment to <120°C* until fault elimination  
• One-time static emergency operation up to an insulating fluid temperature of 140°C* in the oil compartment permissible for a maximum of 48 hours |
| On-load tap-changer switches to static operation and message "OLTC Oil Temperature >120°C" (K44) and oil cooling pump does not run (K7/Q4) | **Possibility 1:** Temperature of the insulating fluid in the oil compartment >120°C and temperature in the pump unit <+15°C  
• Pump is blocked by the controller  
• One-time static emergency operation up to an insulating fluid temperature of 140°C* in the oil compartment permissible for a maximum of 48 hours  
• If temperature is exceeded for longer:  
  • Thaw insulating fluid in heat exchanger / oil cooling circuit  
  • Reduce temperature of the insulating fluid in the oil compartment to <120°C*  
**Possibility 2:** Temperature of the insulating fluid in the oil compartment >120°C and temperature in the pump unit >+15°C  
• Contact MR  
• Reduce temperature of the insulating fluid in the oil compartment to <120°C* until fault elimination  
• One-time static emergency operation up to an insulating fluid temperature of 140°C* in the oil compartment permissible for a maximum of 48 hours |
| Tripping of the motor protective switch Q4 (pump) | • Switch on motor protective switch Q4 just once. If motor protective switch Q4 trips again, do not attempt any more tap-change operations and contact MR.  
• Reduce temperature of the insulating fluid in the oil compartment to <120°C* until fault elimination  
• One-time static emergency operation up to an insulating fluid temperature of 140°C* in the oil compartment permissible for a maximum of 48 hours |

Table 7: Fault elimination
*Due to the insulating effect of the oil compartment, the transformer temperature is approximately 10°C higher than the oil compartment interior temperature

7.1 Tripping the protective relay and re-commissioning the transformer

**WARNING**

**Danger of explosion!**

Explosive gases in the protective relay can deflagrate or explode and result in severe injury or death.

► Wait 15 minutes after switching off the transformer before beginning further work on the protective relay so that the gases can dissipate.

► Ensure that there are no ignition sources such as naked flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the immediate surroundings and that none occur.

► De-energize all auxiliary circuits before beginning work.

► Do not operate any electrical devices during the work (e.g. risk of sparks from impact wrench).

**WARNING**

**Danger of death or severe injury!**

Danger of severe injury or death if on-load tap-changer and transformer are insufficiently tested.

► Be sure to contact Maschinenfabrik Reinhausen to check on-load tap-changer and transformer if the protective relay has tripped.

► Only use the equipment again when you are sure there is no damage to the on-load tap-changer or transformer.

When the circuit breakers have been tripped by the protective relay, proceed as follows:

1. Establish time of tripping.
2. Determine operating position of on-load tap-changer.
3. As a precaution, block the motor-drive unit by tripping the motor protective switch to prevent the on-load tap-changer from being actuated by remote control.
4. Check the on-load tap-changer head cover. If insulating fluid is leaking, close the oil conservator stop valve immediately.
5. Check whether the flap valve of the protective relay is in the OFF or OPERATION position.

7.1.1 Flap valve in OPERATION position

If the flap valve is in the OPERATION position, there may be a fault in the tripping circuit. Check the tripping circuit in this case. If you are not able to clarify why the protective relay tripped, be sure to contact Maschinenfabrik Reinhausen to check the on-load tap-changer.
7.1.2 Flap valve in OFF position

If the flap valve is in the OFF position, proceed as follows:
1. Ensure that the transformer is not started up under any circumstances.
2. Contact and inform Maschinenfabrik Reinhausen of the following:
   - Serial number of protective relay and on-load tap-changer
   - What was the load of the transformer at the instant of tripping?
   - Was the on-load tap-changer moved immediately before or during tripping?
   - Did any other protective devices of the transformer respond at the instant of tripping?
   - Were switching operations in the network being carried out at the instant of tripping?
   - Were overvoltages registered at the instant of tripping?
3. Take further action in agreement with Maschinenfabrik Reinhausen.

7.1.3 Re-commissioning the transformer

Once the reason for the protective relay tripping has been established and remedied, you can re-commission the transformer:
1. Check the protective relay [Section 6.3.4, Page 229].
2. Commission the transformer.
8 Technical data

An overview of all key technical data for the on-load tap-changer and motor-drive unit exists in the form of separate documents, which are available on request.

8.1 Technical data for on-load tap-changer

8.1.1 On-load tap-changer properties

<table>
<thead>
<tr>
<th>On-load tap-changer</th>
<th>VRM I 501</th>
<th>VRM I 802</th>
<th>VRM I 1203(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum rated through-current (I_{\text{rm}}) [A]</td>
<td>500</td>
<td>800</td>
<td>1 200</td>
</tr>
<tr>
<td>Rated short-time current [kA]</td>
<td>5</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Rated duration of short-circuits [s]</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Rated peak withstand current [kA]</td>
<td>12.5</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Maximum rated step voltage (U_{\text{irm}}) [V]</td>
<td>3 000</td>
<td>3 000</td>
<td>3 000</td>
</tr>
<tr>
<td>Step capacity (P_{\text{st}}) [kVA]</td>
<td>1 500</td>
<td>2 400</td>
<td>3 000</td>
</tr>
<tr>
<td>Rated frequency [Hz]</td>
<td>50…60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Electrical data for VACUTAP® VRM I/II/III

\(^1\) For on-load tap-changer VACUTAP® VRM I 1203 with a rated through-current \(I_{\text{r}} > 1,000\) A, contact Maschinenfabrik Reinhausen GmbH regarding the permissible overload and number of tap-change operations.

<table>
<thead>
<tr>
<th>Mechatanical data for VACUTAP® VRM I/II/III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of operating positions</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Number of equipped sectors</td>
</tr>
<tr>
<td>Selector sizes</td>
</tr>
<tr>
<td>Dimensions</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Displacement and oil volume</td>
</tr>
</tbody>
</table>

Table 9: Mechanical data for VACUTAP® VRM I/II/III
8.1.2 Permissible ambient conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature during operation</td>
<td>-25…+50°C</td>
</tr>
</tbody>
</table>
| Temperature of the insulating fluid in the transformer in operation | Normal temperature range: -15…+105°C: continuous  
Increased temperature range: 105…130°C: max. 8 hours/day, max. 720 hours/year  
130…150°C: max. 8 hours/day, max. 240 hours/year |
| Temperature of the insulating fluid in the oil compartment in operation | -15…+120°C                                            |
| Transport temperature, storage temperature          | -40…+50°C                                              |
| Drying temperatures                                  | See installation and commissioning instructions, chapter "Assembly" |
| Compressive strength                                 | See technical data TD 61 – general section             |
| Insulating fluids                                    | Synthetic ester fluid (IEC 61099): Midel 7131  
Other insulating fluids on request                   |
| Installation height of the oil conservator           | See technical data TD 61 – general section             |
| Installation height above sea level                  | See technical data TD 61 – general section             |

Table 10: Permissible ambient conditions

8.2 Technical data for protective relay

General technical data

The technical data for the protective relay RS 2001 is listed in the following. In accordance with DIN EN 60255-1, operational accuracy = base accuracy

<table>
<thead>
<tr>
<th>Housing</th>
<th>Outdoor model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of protection</td>
<td>IP65</td>
</tr>
<tr>
<td>Relay actuation</td>
<td>Flap valve with aperture</td>
</tr>
<tr>
<td>Weight</td>
<td>approx. 3.5 kg</td>
</tr>
</tbody>
</table>
| Oil flow speed of available types when tripping (oil temperature 20°C) | 0.65 ± 0.15 m/s  
1.20 ± 0.20 m/s  
3.00 ± 0.30 m/s  
4.80 ± 0.30 m/s |

Table 11: General technical data

Tripping switch

The protective relay is supplied with several independent dry-reed magnetic switches. These can be designed as normally open (NO) or normally closed (NC) contacts and are electrically isolated from each other.
**Electrical data for normally closed (NC) dry-reed magnetic switch**

**Electrical data**

<table>
<thead>
<tr>
<th>DC switching capacity</th>
<th>1.2 W…200 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC switching capacity (50 Hz)</td>
<td>1.2 VA…400 VA</td>
</tr>
<tr>
<td>Switching voltage AC/DC</td>
<td>24 V…250 V</td>
</tr>
<tr>
<td>Switched current AC/DC</td>
<td>4.8 mA…2 A</td>
</tr>
</tbody>
</table>

Table 12: Electrical data

**Switching capacity (switching load on an off)**

| Minimum switched current AC/DC (lowest voltage) | 50 mA (at 24 V) |
| Minimum switched current AC/DC (highest voltage) | 4.8 mA (at 250 V) |
| Maximum switched current DC (highest current)   | 1.6 A (at 125 V with L/R = 40 ms) |
| Maximum switched current DC (highest voltage)   | 0.9 A (at 250 V with L/R = 40 ms) |
| Maximum switched current AC (highest current)   | 2 A (at 125 V with cos φ = 0.6) |
| Maximum switched current AC (highest voltage)   | 1.6 A (at 250 V with cos φ = 0.6) |
| Switching operations             | 1,000 cycles |

Table 13: Switching capacity (switching load on an off)

**Dielectric strength**

| AC dielectric strength between all voltage-carrying connections and the grounded parts | 2,500 V, 50 Hz, test duration 1 minute |
| AC dielectric strength between the opened contacts                                | 2,000 V, 50 Hz, test duration 1 minute |

Table 14: Dielectric strength

**Electrical data for normally open (NO) dry-reed magnetic switch**

**Electrical data**

<table>
<thead>
<tr>
<th>DC switching capacity</th>
<th>1.2 W…250 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC switching capacity (50 Hz)</td>
<td>1.2 VA…400 VA</td>
</tr>
<tr>
<td>Switching voltage AC/DC</td>
<td>24 V…250 V</td>
</tr>
<tr>
<td>Switched current AC/DC</td>
<td>4.8 mA…2 A</td>
</tr>
</tbody>
</table>

Table 15: Electrical data
Switching capacity (switching load on an off)

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum switched current AC/DC (lowest voltage)</td>
<td>50 mA (at 24 V)</td>
</tr>
<tr>
<td>Minimum switched current AC/DC (highest voltage)</td>
<td>4.8 mA (at 250 V)</td>
</tr>
<tr>
<td>Maximum switched current DC (highest current)</td>
<td>2 A (at 125 V with L/R = 40 ms)</td>
</tr>
<tr>
<td>Maximum switched current DC (highest voltage)</td>
<td>1 A (at 250 V with L/R = 40 ms)</td>
</tr>
<tr>
<td>Maximum switched current AC (highest current)</td>
<td>2 A (at 125 V with cos φ = 0.6)</td>
</tr>
<tr>
<td>Maximum switched current AC (highest voltage)</td>
<td>1.6 A (at 250 V with cos φ = 0.6)</td>
</tr>
<tr>
<td>Switching operations</td>
<td>1,000 cycles</td>
</tr>
</tbody>
</table>

Table 16: Switching capacity (switching load on an off)

Dielectric strength

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC dielectric strength between all voltage-carrying connections and the grounded parts</td>
<td>2,500 V, 50 Hz, test duration 1 minute</td>
</tr>
<tr>
<td>AC dielectric strength between the opened contacts</td>
<td>2,000 V, 50 Hz, test duration 1 minute</td>
</tr>
</tbody>
</table>

Table 17: Dielectric strength

Ambient conditions

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature Ta</td>
<td>-40°C…+50°C</td>
</tr>
<tr>
<td>Oil temperature</td>
<td>&lt;130 °C</td>
</tr>
<tr>
<td>Air pressure</td>
<td>Corresponds to 0 m…4,000 m above sea level</td>
</tr>
</tbody>
</table>

Table 18: Ambient conditions

8.2.1 Protective relay with several dry-reed magnetic switches

The protective relay is supplied with several independent dry-reed magnetic switches. These can be designed as normally open (NO) or normally closed (NC) contacts and are electrically isolated from each other.
8.2.2 Tests

Electrical safety

<table>
<thead>
<tr>
<th>IEC 61010-1</th>
<th>Safety requirements for electrical measurement and control and regulation equipment and laboratory instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Overvoltage category III</td>
</tr>
<tr>
<td></td>
<td>• Contamination level 2</td>
</tr>
</tbody>
</table>

Table 19: Electrical safety
8.3 Limit values for dielectric strength and water content of on-load tap-changer oil

The following table specifies the limit values for dielectric strength (measured in accordance with IEC 60156) and water content (measured in accordance with IEC60814) of the insulating fluid.

<table>
<thead>
<tr>
<th>Condition</th>
<th>( U_d )</th>
<th>( H_2O )</th>
</tr>
</thead>
<tbody>
<tr>
<td>When commissioning the transformer for the first time</td>
<td>&gt; 60 kV/2.5 mm</td>
<td>( \leq 100 ) ppm</td>
</tr>
<tr>
<td>During operation</td>
<td>&gt; 30 kV/2.5 mm</td>
<td>( \leq 200 ) ppm</td>
</tr>
<tr>
<td>After maintenance</td>
<td>&gt; 50 kV/2.5 mm</td>
<td>( \leq 100 ) ppm</td>
</tr>
</tbody>
</table>

Table 20: Limit values for natural ester in accordance with IEC 62770

<table>
<thead>
<tr>
<th>Condition</th>
<th>( U_d )</th>
<th>( H_2O )</th>
</tr>
</thead>
<tbody>
<tr>
<td>When commissioning the transformer for the first time</td>
<td>&gt; 60 kV/2.5 mm</td>
<td>( \leq 100 ) ppm</td>
</tr>
<tr>
<td>During operation</td>
<td>&gt; 30 kV/2.5 mm</td>
<td>( \leq 400 ) ppm</td>
</tr>
<tr>
<td>After maintenance</td>
<td>&gt; 50 kV/2.5 mm</td>
<td>( \leq 150 ) ppm</td>
</tr>
</tbody>
</table>

Table 21: Limit values for synthetic esters in accordance with IEC 61099
9 Drawings

9.1 Dimensional drawings
ON-LOAD TAP-CHANGER VACUTAP® VR
VR S/M - SELECTOR SIZE B/C/D/DE
INSTALLATION POSITION OF SELECTOR CONNECTION CONTACTS
TECHNICAL DATA

HOUSING: OUTDOOR DESIGN, POWDER COATED RAL 9006 WHITE ALUMINIUM (C5)

HOUSING MATERIAL: SEAWATER RESISTANT ALUMINIUM

PROTECTION TYPE: IP66 ACCORDING TO IEC 60529 (CLOSED DEVICE)

AMBIENT TEMPERATURE: -40°C TO +150°C (-40°F TO +302°F)

OIL TEMPERATURE: -40°C TO +150°C (-40°F TO +302°F)

OPERATING MEDIUM: TRANSFORMER OIL OR AIR

CONNECTION: CABLE GLAND WITH M20x1.5 (CLAMPING AREA 10,8MM TO 12,8MM)

TERMINAL STRIP: SCREW TERMINAL

0.08MM² TO 2.5MM² (SINGLE AND STRANDED WIRE)

0.25MM² TO 1.5MM² (STRANDED WIRE WITH FERRULE)

AWG: 28 TO 12

1ST PT100: 2-WIRE SYSTEM 1x RED(1), 1x WHITE(2)

2ND PT100: 2-WIRE SYSTEM 1x YELLOW(3), 1x BLACK(4)

SENSOR: 2x PT100 ACCORDING TO DIN EN 60751 CLASS B (2-WIRE CIRCUIT)

HIGH VOLTAGE RESISTANCE: 2.0kV / 50HZ / 1MIN. (SENSOR TO SENSOR)

2.0kV / 50HZ / 1MIN. (SENSOR TO GROUND)

CONNECTION ACCORDING TO THE ASSOCIATED CIRCUIT DIAGRAM
9.2 On-load tap-changer head
ON-LOAD TAP-CHANGER
VACUTAP® VR
ON-LOAD TAP-CHANGER HEAD, CENTRIC DRIVE HT DESIGN

E1 = BLEEDING FACILITY FOR ON-LOAD TAP-CHANGER HEAD
E2 = BLEEDING FACILITY FOR SPACE UNDER THE HEAD OUTSIDE THE TAP-CHANGER OIL COMPARTMENT
(SAME PIPE CONNECTION AS R, S OR BLEEDER SCREW CAN BE USED)
Q = CONNECTION FOR OIL RETURN OR TAP CHANGE SUPERVISORY CONTROL
S = CONNECTION FOR OIL RETURN WITH BLEEDER SCREW
R = CONNECTION FOR PROTECTIVE RELAY
A = CONNECTION FOR OIL EXTRACTION
M = DRIVE SIDE OF THE TAP SELECTOR

<table>
<thead>
<tr>
<th>Um (kV)</th>
<th>170</th>
<th>245</th>
<th>300</th>
<th>362</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIMENSION (mm)</td>
<td>(\phi56)</td>
<td>(\phi56)</td>
<td>(\phi56)</td>
<td>(\phi100)</td>
</tr>
<tr>
<td></td>
<td>(148)</td>
<td>(148)</td>
<td>(148)</td>
<td>(185)</td>
</tr>
<tr>
<td></td>
<td>(\phi620)</td>
<td>(\phi620)</td>
<td>(\phi620)</td>
<td>(\phi695)</td>
</tr>
</tbody>
</table>

SCREENING RING ONLY WITH Um=170/245/300/362 kV

LIFTING DEVICE

SUPPORTING FLANGE

Z = CENTERING BOLT

M = DRIVE SIDE OF SELECTOR

ON-LOAD TAP-CHANGER VACUTAP® VR®
SPECIAL DESIGN BELL-TYPE TANKINSTALLATION
The direction of rotation is defined during ordering.
PIPE CONNECTION WITH TAP-CHANGE SUPERVISORY CONTROL BUSHING WITHOUT OIL FILTER UNIT

NOTICE!
The vent screw (2) of the mounted housing (1) has to be on the top.

ON-LOAD TAP-CHANGER HEAD

A 11
REPRESENTED WITHOUT COVER

M20x15
Clamping range for connection cable:
External diameter: 7 - 13 mm

FUNCTION DIAGRAM FOR TAP-CHANGE SUPERVISORY CONTROL SEE MOTOR-DRIVE CONNECTION DIAGRAM

CONNECTION TERMINALS FOR TAP-CHANGE SUPERVISORY CONTROL

WIRING SEE CONNECTION DIAGRAM OF THE MOTOR-DRIVE UNIT

RATED CONTINUOUS CURRENT: 2A
RATED VOLTAGE DC/AC (50Hz): 24V - 250V
DIELECTRIC STRENGTH: 1150V / 50Hz / 1 Min.

DIELECTRIC TEST OF ALL VOLTAGE CARRYING TERMINALS TO GROUND:
2000V AC, 50Hz, TEST-DURATION 1 Min.
9.3 Adjustment plans

- M = DRIVE SIDE OF THE SELECTOR
- A = ON-LOAD TAP-CHANGER TAKE-OFF TERMINAL

DIVERTER SWITCH INSERT
TOP VIEW

1 SECTOR
2 SECTORS
3 SECTORS

DIVERTER SWITCH

SELECTOR COUPLING

GENEVA WHEEL LOWER

SELECTOR

SELECTOR PLANE I

SELECTOR PLANE II

ON-LOAD TAP-CHANGER VACUTAP® VR
VR S/M 1/1/11 - B/C/D/DE - 0 - 12/16 PITCH
ADJUSTMENT PLAN

= DRIVE SIDE OF THE SELECTOR

= ON-LOAD TAP-CHANGER TAKE-OFF TERMINAL

DIVERTER SWITCH INSERT

TOP VIEW

DIVERTER SWITCH

SELECTOR COUPLING

GENEVA WHEEL LOWER

SELECTOR

10 PITCH REPRESENTATION

SELECTOR PLANE I

SELECTOR PLANE II

- DRIVE SIDE OF THE SELECTOR
- ON-LOAD TAP-CHANGER TAKE-OFF TERMINAL

DIVERTER SWITCH INSERT
TOP VIEW

1 SECTOR

DIVERTER SWITCH

SELECTOR COUPLING

GENEVA WHEEL LOWER

SELECTOR
10 PITCH REPRESENTATION

SELECTOR PLANE I

SELECTOR PLANE II

10191W, 12231W, 14271W, 16311W, 18351W

= DRIVE SIDE OF THE SELECTOR

= ON-LOAD TAP-CHANGER TAKE-OFF TERMINAL

DIVERTER SWITCH INSERT

TOP VIEW

SELECTOR COUPLING

GENEVA WHEEL LOWER

SECTOR 2

SECTOR 3

SELECTOR PLANE I

SELECTOR PLANE II

10 PITCH REPRESENTATION

1019W, 1223W, 1427W, 1631W, 1835W

10073W...18353W

= DRIVE SIDE OF THE SELECTOR

= ON-LOAD TAP-CHANGER TAKE-OFF TERMINAL

ON-LOAD TAP-CHANGER

DIVERTER SWITCH INSERT
TOP VIEW

1 SECTOR
3 SECTORS

SELECTOR COUPLING

GENEVA WHEEL LOWER

SELECTOR
UPPER SELECTOR PLANE
LOWER SELECTOR PLANE

ON-LOAD TAP-CHANGER VACUTAP® VR
VRS WITH MULTIPLE COARSE CHANGE-OVER SELECTOR, 10 PITCH
ADJUSTMENT PLAN / 2-5 COARSE TAP CONNECTIONS

- = DRIVE SIDE OF THE SELECTOR
-A = ON-LOAD TAP-CHANGER TAKE-OFF TERMINAL

DIVERTER SWITCH INSERT
TOP VIEW

DIVERTER SWITCH

SELECTOR COUPLING

GENEVA WHEEL LOWER

SELECTOR

LOWER SELECTOR PLANE

UPPER SELECTOR PLANE

ON-LOAD TAP-CHANGER VACUTAP® VR
VRS WITH MULTIPLE COARSE CHANGE-OVER SELECTOR, 12 PITCH ADJUSTMENT PLAN / 2-5 COARSE TAP CONNECTIONS

- \( \text{M} \) = DRIVE SIDE OF THE SELECTOR
- \( \text{A} \) = ON-LOAD TAP-CHANGER TAKE-OFF TERMINAL

DIVERTER SWITCH INSERT

TOP VIEW

SELECTOR COUPLING

GENEVA WHEEL LOWER

SELECTOR

LOWER SELECTOR PLANE

UPPER SELECTOR PLANE

- M = DRIVE SIDE OF THE SELECTOR
- A = ON-LOAD TAP-CHANGER TAKE-OFF TERMINAL

ON-LOAD TAP-CHANGER HEAD

DIVERTER SWITCH INSERT
TOP VIEW

DIVERTER SWITCH

SELECTOR COUPLING

GENEVA WHEEL LOWER

SELECTOR

LOWER SELECTOR PLANE

UPPER SELECTOR PLANE

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= DRIVE SIDE OF THE SELECTOR

= ON-LOAD TAP-CHANGER TAKE-OFF TERMINAL

DIvERTER SWITcH INSErT
TOP VIEW

DIvERTER SWITcH

SELEcTOR COUPLING

GEneVA WHEEL LOWER

SELEcTOR

LOWER SELECTOR PLANE

UPPER SELECTOR PLANE

DE-ENERGIZED TAP-CHANGER VACUTAP® VR
VRS WITH MULTIPLE COARSE CHANGE-OVER SELECTOR, 18 PITCH
ADJUSTMENT PLAN / 2-5 COARSE TAP CONNECTIONS
## Glossary

<table>
<thead>
<tr>
<th>DC</th>
<th>IEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct current</td>
<td>The International Electrotechnical Commission (IEC for short) is involved in the preparation and publication of international standards for electrical, electronic and related technologies.</td>
</tr>
<tr>
<td>Dielectric strength</td>
<td></td>
</tr>
<tr>
<td>Material-specific property of isolators [kV/2.5 mm]; maximum electrical field strength without a breakdown (arc)</td>
<td>IP</td>
</tr>
<tr>
<td></td>
<td>Ingress protection</td>
</tr>
<tr>
<td>MR</td>
<td></td>
</tr>
<tr>
<td>Maschinenfabrik Reinhausen GmbH</td>
<td></td>
</tr>
</tbody>
</table>