



# On-load tap-changer OILTAP<sup>®</sup> R

Operating instructions

4427379/01 EN



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We reserve the right to change the technical data, design and scope of supply.

Generally the information provided and agreements made when processing the individual quotations and orders are binding.

The original operating instructions were written in German.



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## 1 Introduction

This technical file contains detailed descriptions for monitoring during operation, fault elimination, and maintenance.

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

Information about installation can be found in the installation and commissioning 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

Tel.: (+49) 9 41/40 90-0

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

### 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:

#### **▲ WARNING**



#### **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:

| Signal word | Definition   |
|-------------|--|
| DANGER      | Indicates a hazardous situation which, if not avoided, will result in death or serious injury.   |
| WARNING     | Indicates a hazardous situation which, if not avoided, could result in death or serious injury.  |
| CAUTION     | Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury. |
| NOTICE      | Indicates measures to be taken to prevent damage to property.                                    |

Table 1: Signal words in warning notices

Pictograms warn of dangers:






| Pictogram   | Definition                              |
|---|---|
|    | Warning of a danger point               |
|    | Warning of dangerous electrical voltage |
|    | Warning of combustible substances       |
|   | Warning of danger of tipping            |
|  | Warning of danger of crushing           |

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

- Read this technical file through 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.
- Read and 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 for the user or impairment of the product and other material assets due to the function may arise in the event of improper use.

### 2.1 Appropriate use

The product is an on-load tap-changer and adjusts the transmission ratio of transformers without interrupting the load flow. The product is designed solely for use in electrical energy systems and facilities. 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 product, then the product does not present any danger to people, property or the environment. This applies throughout the service life of the product, from delivery, installation and operation to removal and disposal.

The following is considered intended use:

- Use the product only with the transformer/motor-drive unit specified in the order.
- 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 valid for the product and the year of issue on the nameplate.
- Operate the product in accordance with this provided 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 the scope of delivery for the intended purpose and in accordance with the specifications of this technical document.

#### 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 alternating current with a curve form symmetrical to the zero axis and can switch 2 times the rated through-current  $I_r$  at its rated step voltage  $U_{ir}$ .



Exceeding the rated step voltage  $U_{ir}$  by up to 10% for a short period is permitted as long as the rated step capacity  $P_{SIN}$  permissible for this step voltage 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 poses a danger to life and limb.

- Wear appropriate personal protective equipment such as a helmet, work gloves, etc. for the respective activity.
- 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.

### Safety markings

Warning signs and safety information plates are safety markings on the product. They are an important aspect of the safety concept.

- Observe all safety markings on the product.
- Make sure all safety markings on the product remain intact and legible.
- Replace safety markings that are damaged or missing.

### Ambient conditions

To ensure reliable and safe operation, the product must only be operated under the ambient conditions specified in the technical data.

- Observe the specified operating conditions and requirements for the installation location.

### Auxiliary materials and operating materials

Auxiliary materials and operating materials not approved by the manufacturer can lead to personal injury, damage to property and malfunctions of the product.

- Only use insulating fluids [► Section 8.1, Page 53] approved by the manufacturer.
- Only use conductive and grounded hoses, pipes and pump equipment that are approved for flammable liquids.



- Only use lubricants and auxiliary materials approved by the manufacturer.
- Contact the manufacturer.

### **Modifications and conversions**

Unauthorized or inappropriate changes to the product may lead to personal injury, material damage and operational faults.

- Only modify the product after consultation with Maschinenfabrik Reinhausen GmbH.

### **Spare parts**

Spare parts not approved by Maschinenfabrik Reinhausen GmbH may lead to physical injury, damage to the product and malfunctions.

- Only use spare parts that have been approved by Maschinenfabrik Reinhausen GmbH.
- Contact Maschinenfabrik Reinhausen GmbH.

## **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.

|                            |  |
|----------------------------|--|
| <b>Protective clothing</b> | 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. |
| <b>Safety shoes</b>        | To protect against falling heavy objects and slipping on slippery surfaces.  |
| <b>Safety glasses</b>      | To protect the eyes from flying parts and splashing liquids.   |
| <b>Visor</b>               | To protect the face from flying parts and splashing liquids or other dangerous substances.   |
| <b>Hard hat</b>            | To protect against falling and flying parts and materials.   |
| <b>Hearing protection</b>  | To protect against hearing damage.   |
| <b>Protective gloves</b>   | To protect against mechanical, thermal, and electrical hazards.  |

Table 3: Personal protective equipment



### 3 Product description

#### 3.1 On-load tap-changer

##### 3.1.1 Function description

On-load tap-changers are used to adjust the transmission ratio of transformers without interrupting the load flow. This makes it possible to compensate for aspects such as fluctuations in voltage occurring in the power transmission grid. 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.

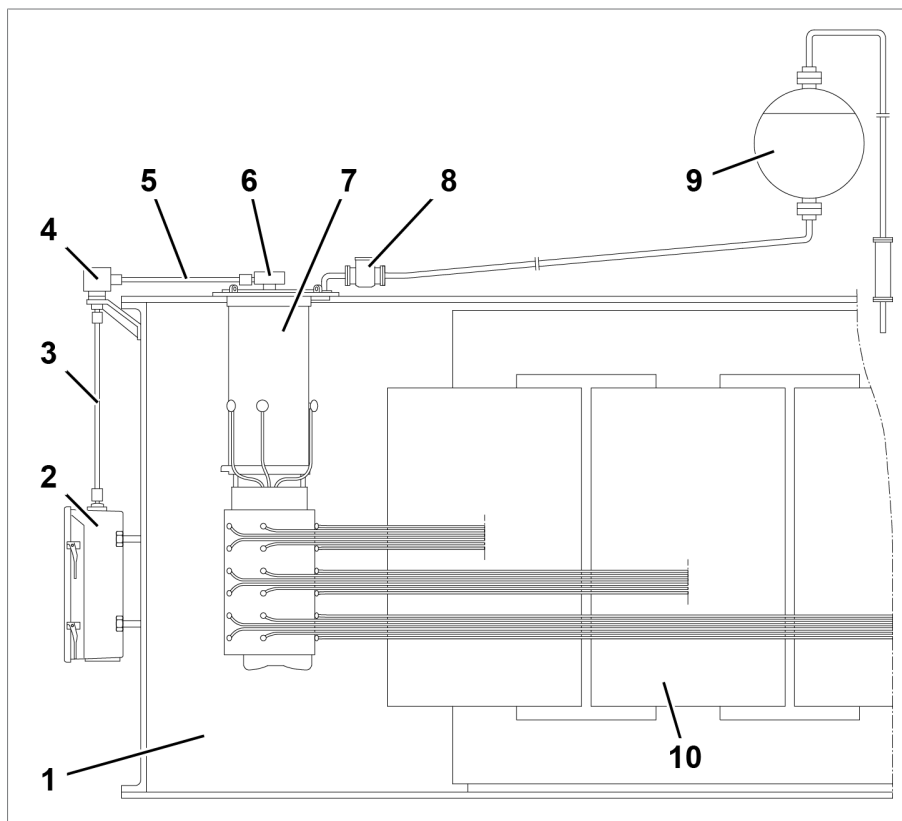


Figure 1: System overview of on-load tap-changer, transformer

|                        |                       |
|------------------------|-----------------------|
| 1 Transformer tank     | 6 Upper gear unit     |
| 2 Motor-drive unit     | 7 On-load tap-changer |
| 3 Vertical drive shaft | 8 Protective relay    |

|                          |                                   |
|--------------------------|-----------------------------------|
| 4 Bevel gear             | 9 Oil conservator                 |
| 5 Horizontal drive shaft | 10 Active part of the transformer |

### 3.1.2 Setup/versions

The on-load tap-changer consists of the on-load tap-changer head, oil compartment with built-in diverter switch insert, and the tap 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.

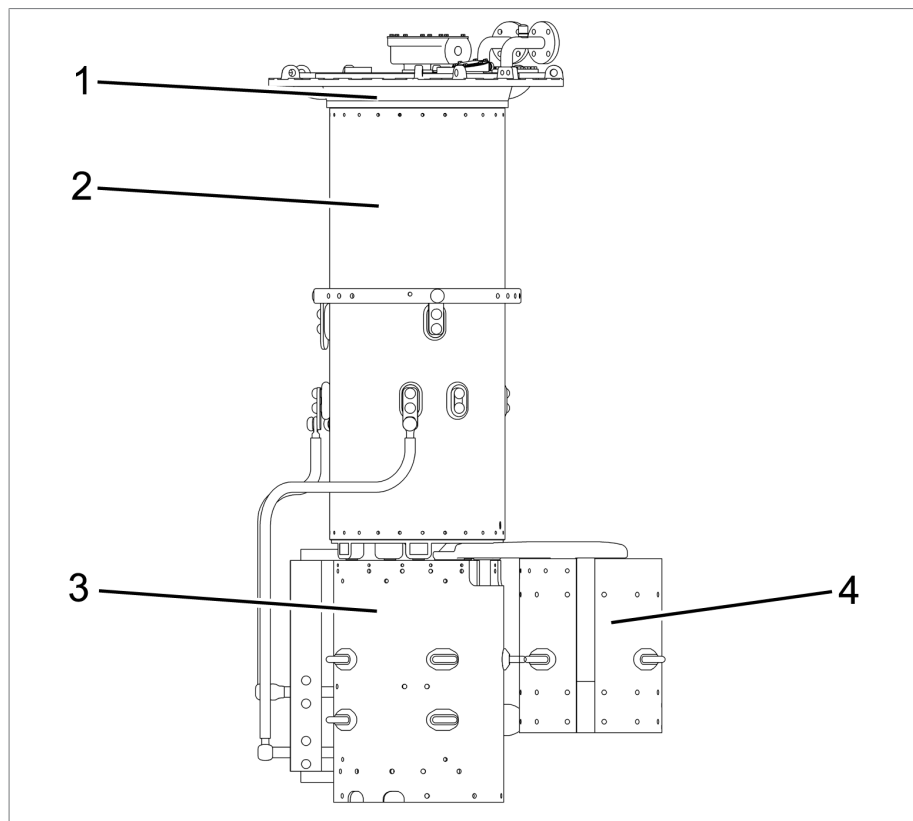


Figure 2: OILTAP® R on-load tap-changer

|                            |                        |
|----------------------------|------------------------|
| 1 On-load tap-changer head | 3 Tap selector         |
| 2 Oil compartment          | 4 Change-over selector |

### 3.1.2.1 Pipe connections

The on-load tap-changer head features 4 pipe connections for different 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 control can be freely swiveled once the pressure ring is loosened.

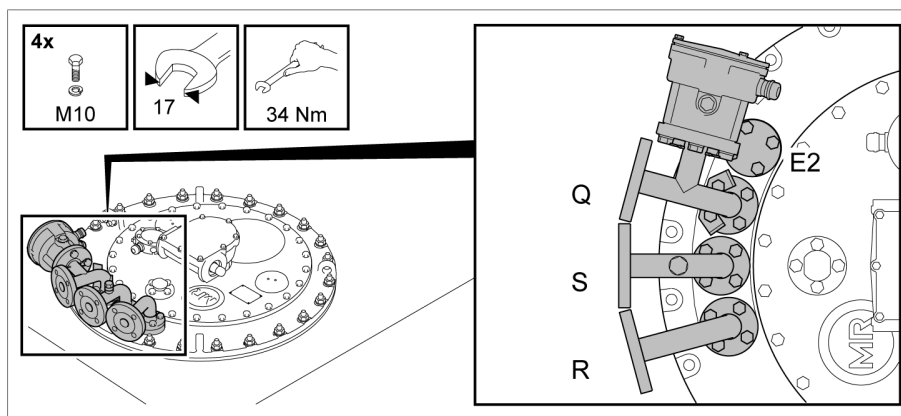


Figure 3: Pipe connections with pipe bends

#### Pipe connection Q

The pipe connection Q is closed with a blank cover. Depending on the on-load tap-changer type, either the connection cables of the tap-change supervisory device delivered as an option are routed through the pipe connection, or the oil filter unit is connected to the pipe connection.



The functions of the R and Q pipe connections can be interchanged.

#### Pipe connection S

The pipe bend on pipe connection S features a vent screw and can be connected to a pipe that ends with a drain valve on the side of the transformer tank at operating height. If the on-load tap-changer is fitted with an oil suction pipe, the on-load tap-changer can be completely emptied via pipe connection S.

#### Pipe connection R

Pipe connection R is intended for attachment of the protective relay and connection of the on-load tap-changer oil conservator and can be interchanged with pipe connection Q.

### 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, filling with insulating fluid and transportation of the transformer.

### 3.1.3 Nameplate and serial number

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

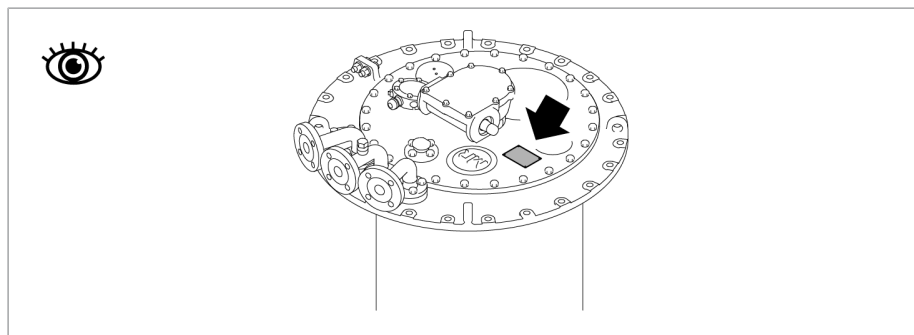


Figure 4: Nameplate

### 3.1.4 Protective devices

The on-load tap-changer is equipped with the following protective devices.

#### 3.1.4.1 Protective relay

##### 3.1.4.1.1 Function description

The protective relay is looped into the circuit breaker tripping circuit. 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.



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.

3.1.4.1.2 Design/versions

Front view

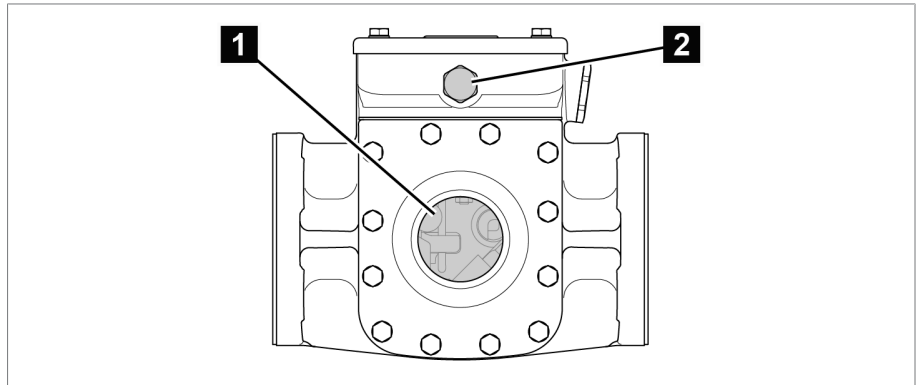


Figure 5: Protective relay RS 2001

1 Inspection window

2 Pressure equalization element

Rear view

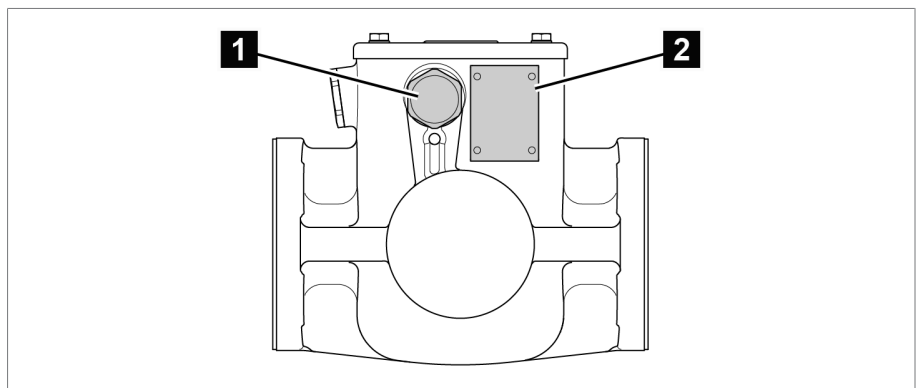


Figure 6: Protective relay RS 2001

1 Dummy plug

2 Nameplate



The protective relay RS 2001/R has an extra inspection window on the rear.

View from above

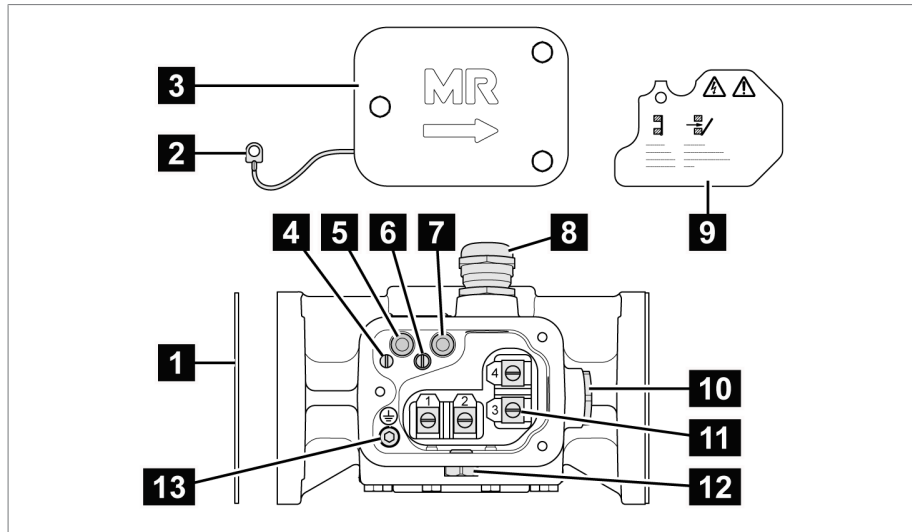


Figure 7: Protective relay RS 2001

|  |   |
|--|---|
| 1 Gasket   | 2 Potential tie-in                        |
| 3 Terminal box cover                                       | 4 Slotted head screw for potential tie-in |
| 5 OPERATION (reset) test button                            | 6 Slotted head screw for protective cover |
| 7 OFF (test tripping) test button                          | 8 Cable gland                             |
| 9 Protective cover   | 10 Dummy plug                             |
| 11 Connection terminal                                     | 12 Pressure equalization element          |
| 13 Cylinder head screw for protective conductor connection |   |



The protective relays RS 2003 and RS 2004 have a 1/2"-14NPT adapter in place of the cable gland.

### 3.1.4.1.3 Nameplate

The nameplate is on the back of the protective relay.

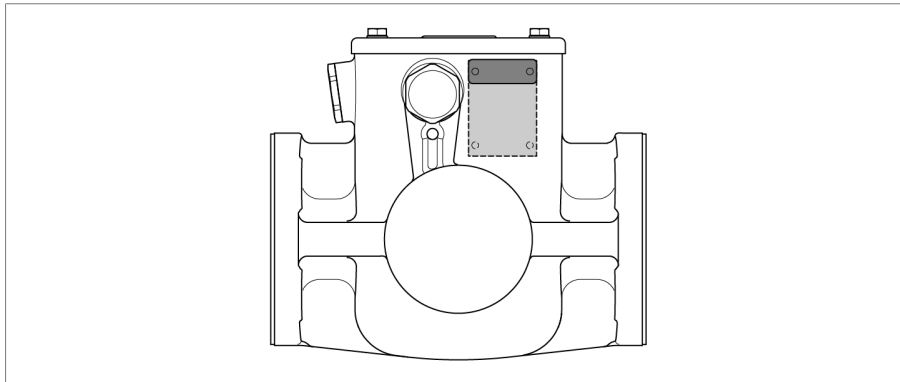


Figure 8: Nameplate

### 3.1.4.2 Pressure monitoring device DW

#### 3.1.4.2.1 Function description

The DW 2000 pressure monitoring device protects the on-load tap-changer from impermissible pressure increases, contributing to the safety of the transformer. The pressure monitoring device is installed on the outside of the on-load tap-changer and is tripped by impermissible static and dynamic pressures in the on-load tap-changer oil compartment.

The pressure monitoring device uses a concept where a corrugated tube acts as a barometer together with a spring providing counter force. This assembly is mechanically linked to the sensor on the snap-action switch.

The pressure increase activates the sensor on the snap-action switch, which flips into the OFF position. This triggers the circuit breaker and de-energizes the transformer. The sensor on the snap-action switch has to be reset to the initial position by hand after tripping.

Low-energy interference does not cause the pressure monitoring device to trip since the required tripping pressure is not reached. The tripping pressure is set at the factory and prevented from being changed.

The pressure monitoring device responds to large pressure increases faster than the protective relay. The protective relay is part of the standard MR protection system and comes as standard.



Additional use of a pressure monitoring device also requires installation of the provided protective relay.

The features and characteristics of the pressure monitoring device comply with the respective applicable version of IEC publication 60214-1.



Diverter switch operations at the rated switching capacity or permitted overload do not cause the pressure-operated relay to trip.



The pressure-operated relay responds to a pressure change and not to gas accumulation under the pressure-operated relay. Gas accumulation under the pressure-operated relay is normal.

### 3.1.4.2.2 Design/versions

There are two variants of the pressure monitoring device:

- DW 2000 for vertical installation
- DW 2000 for horizontal installation

The housing and the cover cap of the pressure monitoring device consist of lightweight, corrosion-resistant metal.

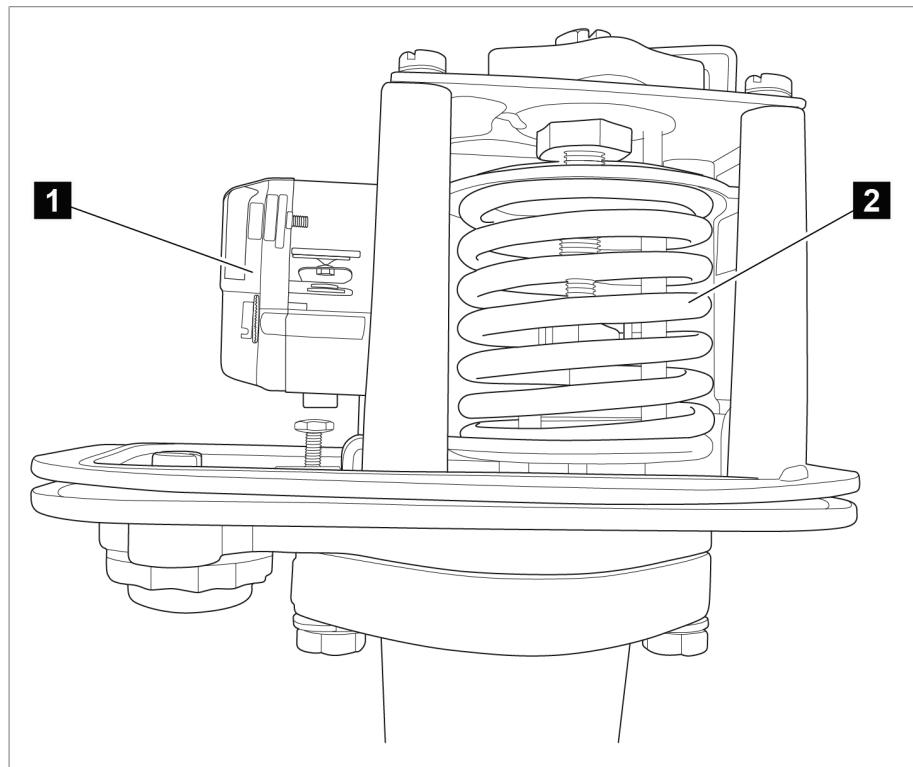


Figure 9: Snap-action switch and pressure measuring element

1 Snap-action switch

2 Pressure measuring element

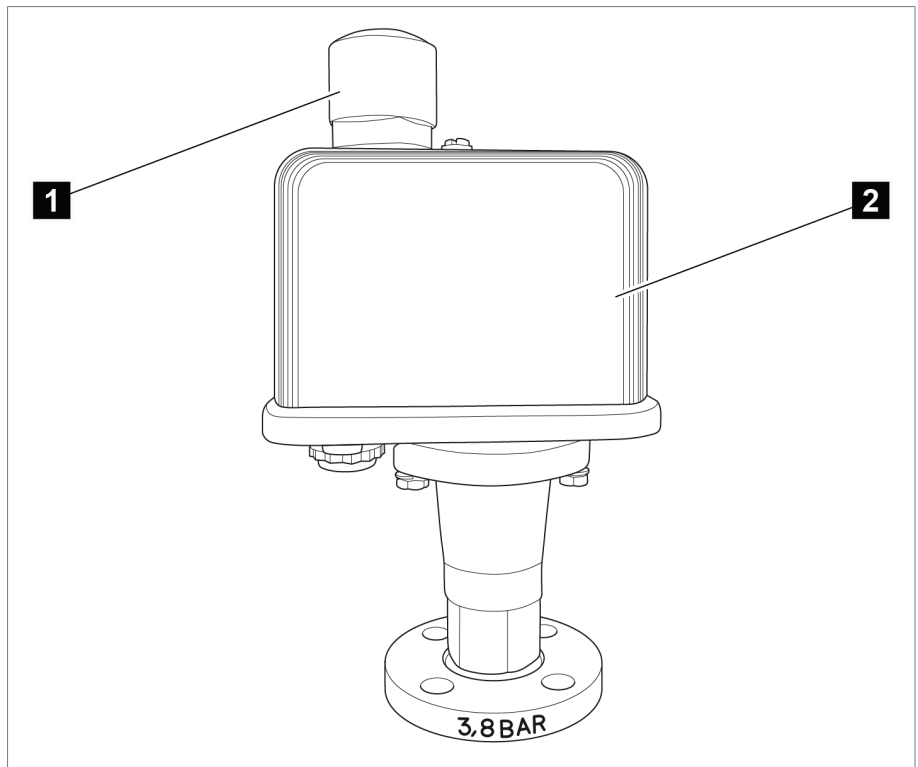


Figure 10: Pressure monitoring device with cover cap and ventilation

1 Ventilation

2 Cover cap

### 3.1.4.3 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.

### 3.1.4.4 Pressure relief device MPreC®

On request, MR will supply a pre-fitted MPreC® pressure relief device in place of the rupture disk. This device responds to a defined overpressure in the oil compartment of the on-load tap-changer.

The on-load tap-changer therefore meets the requirements of IEC 60214-1 regarding pressure relief devices.

### 3.1.4.5 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.



### 3.1.4.6 Temperature monitoring

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



### 3.2 Drive shaft

#### 3.2.1 Function description

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

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.

### 3.2.2 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.

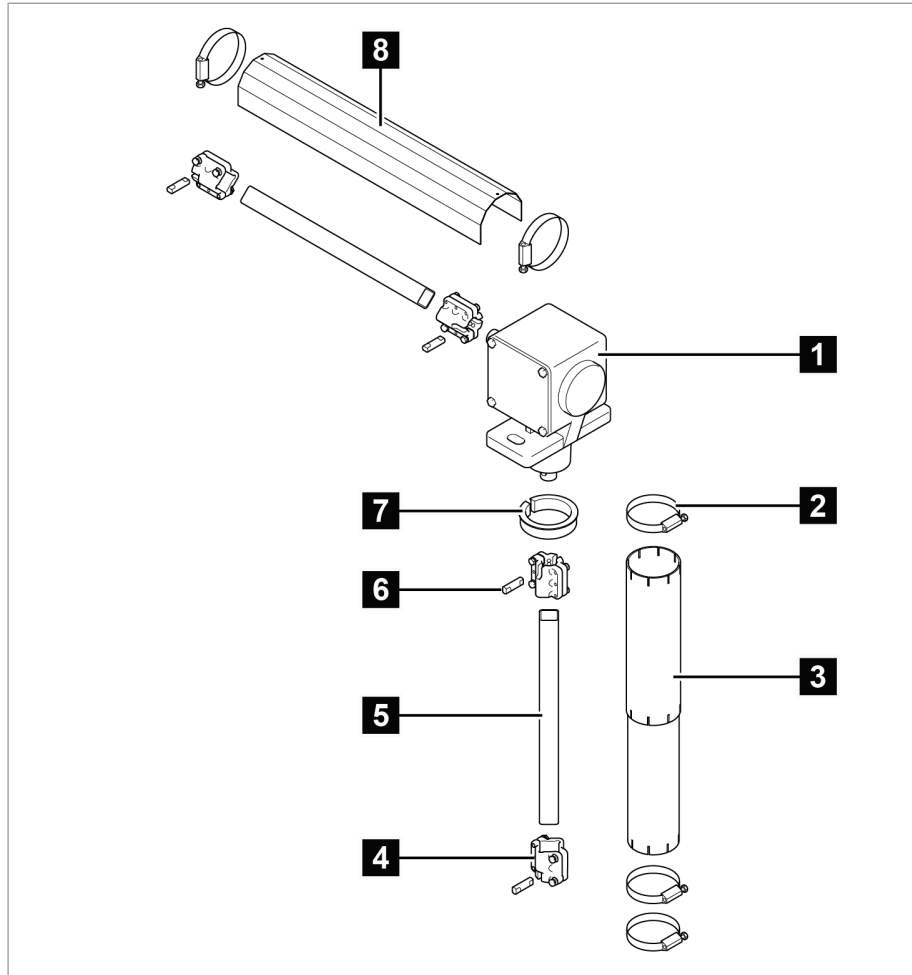


Figure 11: Components of the drive shaft

|                              |                    |
|------------------------------|--------------------|
| 1 Bevel gear                 | 2 Hose clip        |
| 3 Telescopic protective tube | 4 Coupling bracket |
| 5 Square tube                | 6 Coupling bolt    |
| 7 Adapter ring               | 8 Protective cover |

3.2.2.1 Drive shaft without cardan joint and without insulator

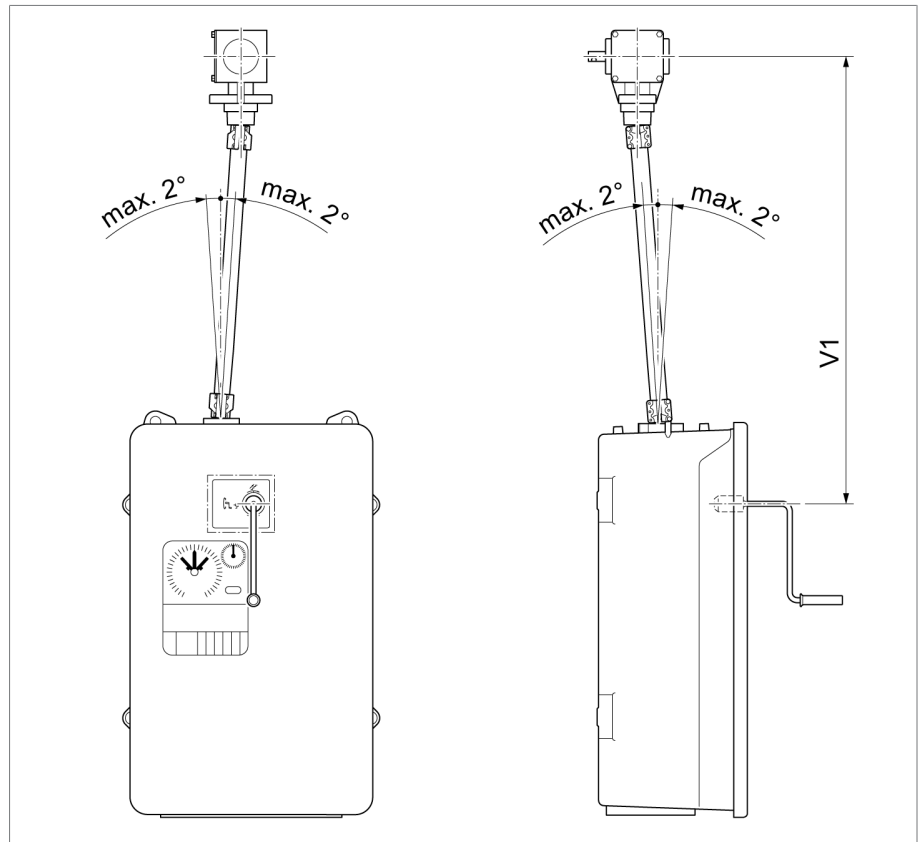


Figure 12: Drive shaft without cardan joint and without insulator (= standard version)

| Configuration   | V 1 min | Intermediate bearing  |
|---|---------|---|
| Middle of hand crank – middle of bevel gear (maximum permissible axial offset 2°) | 536 mm  | When the maximum value of 2472 mm is exceeded, it is necessary to use an intermediate bearing.<br>V 1 ≤ 2472 mm (without intermediate bearing)<br>V 1 > 2472 mm (with intermediate bearing) |

3.2.2.2 Drive shaft without cardan joint and with insulator

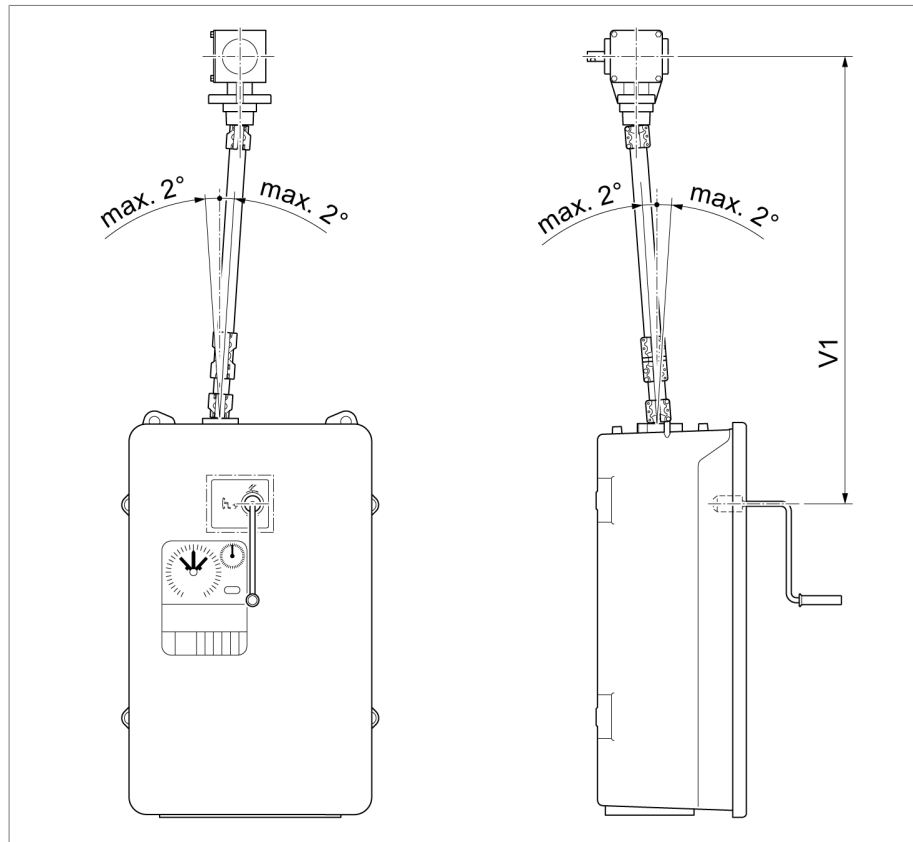


Figure 13: Drive shaft without cardan joint and with insulator (= special model)

| Configuration   | V 1 min | Intermediate bearing  |
|---|---------|---|
| Middle of hand crank – middle of bevel gear (maximum permissible axial offset 2°) | 706 mm  | When the maximum value of 2472 mm is exceeded, it is necessary to use an intermediate bearing.<br>V 1 ≤ 2472 mm (without intermediate bearing)<br>V 1 > 2472 mm (with intermediate bearing) |

3.2.2.3 Drive shaft with cardan joints, without insulator

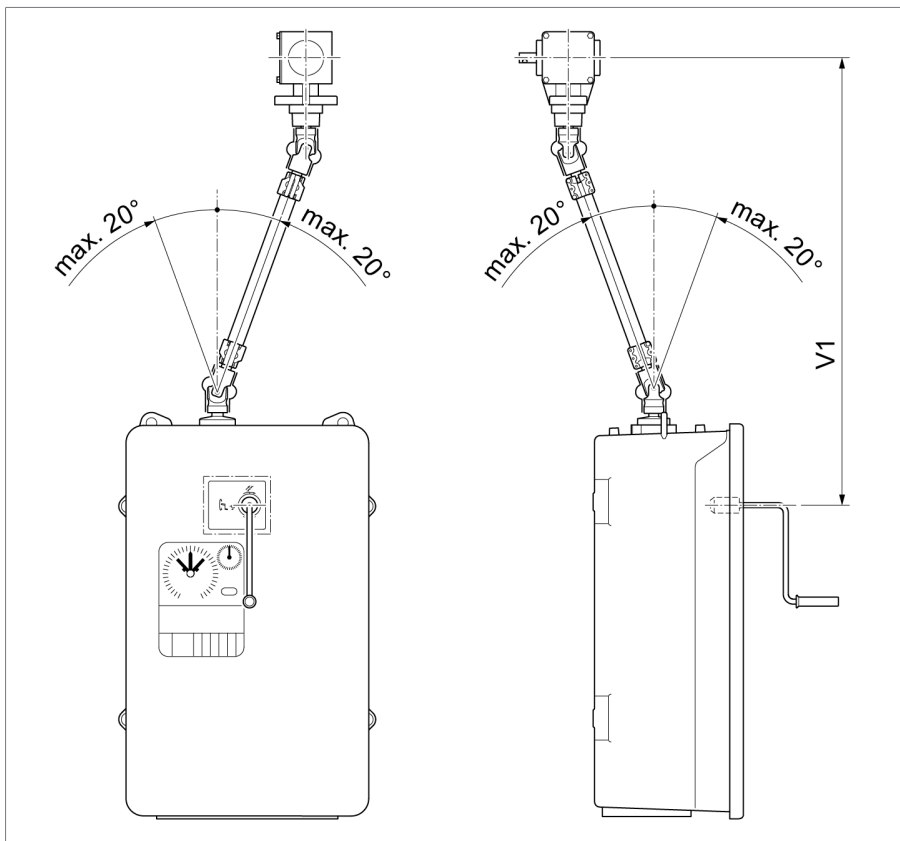


Figure 14: Drive shaft with cardan joints, without insulator (= special model)

| Configuration  | V 1 min [mm] | Intermediate bearing for [mm] |
|--|--------------|-------------------------------|
| Middle of hand crank – middle of bevel gear (maximum permissible axial offset 20°) | 798          | V 1 > 2564                    |

3.2.2.4 Drive shaft with cardan joints, with insulator

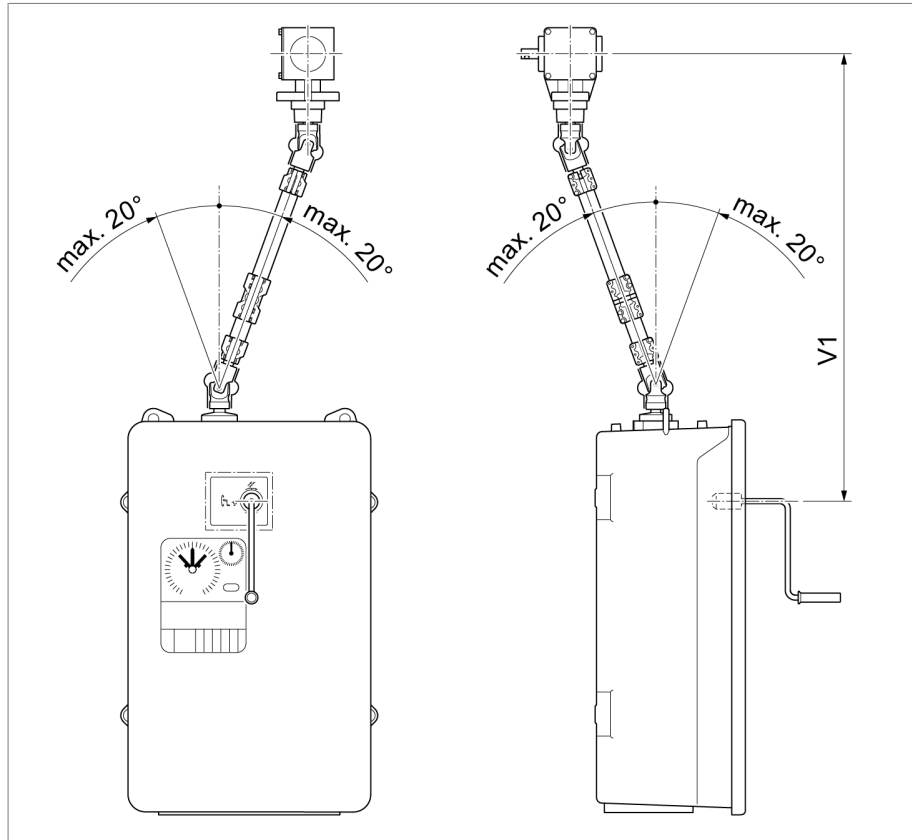


Figure 15: Drive shaft with cardan joints, with insulator (= special model)

| Configuration  | V 1 min [mm] | Intermediate bearing for [mm] |
|--|--------------|-------------------------------|
| Middle of hand crank – middle of bevel gear (maximum permissible axial offset 20°) | 978          | V 1 > 2772                    |



### 3.3 OF 100 Oil Filter Unit

The purpose of the OF 100 oil filter unit is to clean the on-load tap-changer's insulating fluid with the paper filter insert and to clean and dry the fluid with the combined filter insert.

For on-load tap-changers where the number of tap-change operations per year is higher than 15,000, we recommend the use of the OF 100 oil filter unit with paper filter insert. This can extend the intervals between maintenance.

For more information, consult the MR operating instructions "OF 100 oil filter unit".

You must use the OF 100 oil filter unit with combined filter insert for OILTAP® R on-load tap-changers with operating voltage  $U_b$  from 245 kV and voltage for equipment  $U_m$  from 300 kV.

## 4 Commissioning

### ▲ WARNING



#### 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.

### ▲ WARNING



#### Danger of explosion!

Overloading the on-load tap-changer can lead to explosion. Spraying hot insulating fluid and flying parts can lead 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.

### 4.1 Commissioning transformer at operating site

#### 4.1.1 Filling the oil compartment of the on-load tap-changer with insulating fluid

### NOTICE

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

Unsuitable insulating fluids cause damage to the on-load tap-changer.

- ▶ Only use insulating fluids [▶ Section 8.1, Page 53] approved by the manufacturer.

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.

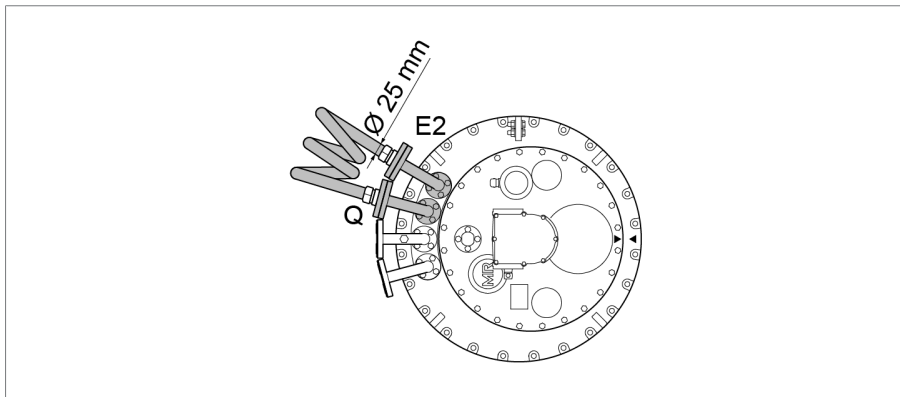


Figure 16: Connecting lead between E2 and Q

3. Fill on-load tap-changer with new insulating fluid using one of the two free pipe connections of the on-load tap-changer head.

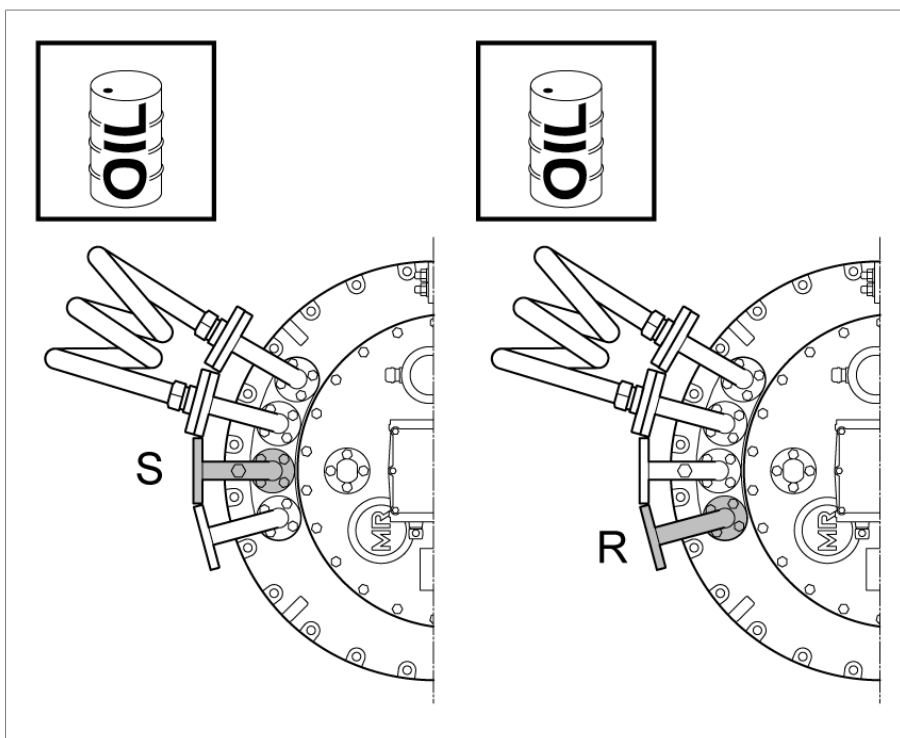


Figure 17: Pipe connections S and R

4. Take an insulating fluid sample from the oil compartment.
5. Record the temperature of the sample immediately after the sample is taken.
6. Determine the dielectric strength and water content at a sample temperature of  $20\text{ °C} \pm 5\text{ °C}$ . The dielectric strength and water content must comply with the limit values specified in the technical data.

## 4.1.2 Bleeding on-load tap-changer head and suction pipe

### 4.1.2.1 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.

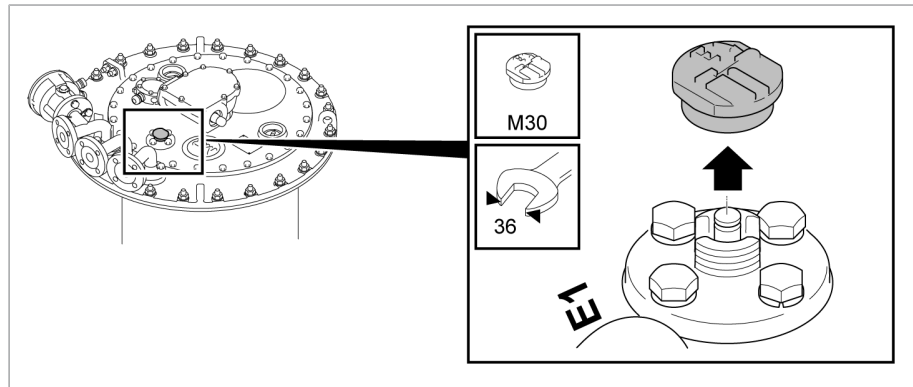


Figure 18: Screw cap

3. Use screwdriver to lift valve tappet on air-vent valve E1 and bleed on-load tap-changer head.

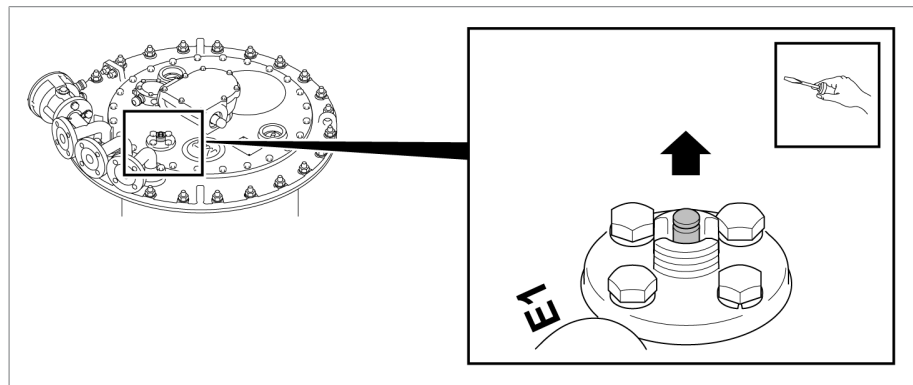


Figure 19: Valve tappet

4. Seal air-vent valve E1 with screw cap (tightening torque 10 Nm).

**4.1.2.2 Bleeding suction pipe on pipe connection S**

1. Remove screw cap from pipe connection S.

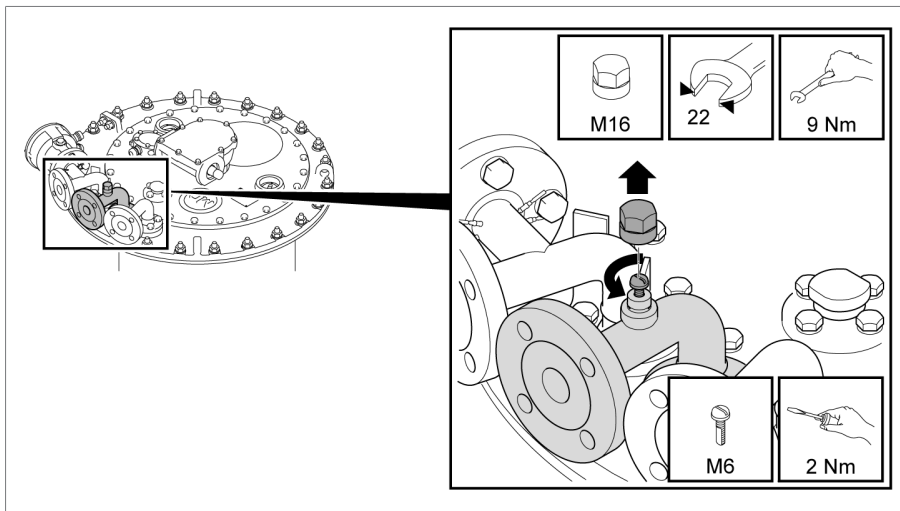


Figure 20: Screw cap

2. **NOTICE!** An incompletely bled suction pipe significantly impairs the insulation capability of the on-load tap changer to ground. Open vent screw and bleed suction pipe completely.
3. Close vent screw.
4. Seal vent screw with screw cap.

**4.1.3 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 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.

**4.1.4 Checking protective relay****4.1.4.1 Checking protective relay (RS 2001, 2001/V, 2001/H, 2001/E, 2001/5, 2001/R, 2001/T, 2003)**

- ✓ 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.

### 4.1.4.2 Checking protective relay (RS 2004)

- ✓ Check that the protective relay is functioning correctly before commissioning the transformer:
  1. Ensure that the flap valve is in the OPERATION position.
  2. Leave the transformer's danger zone.
  3. Close the transformer's circuit breaker with isolating switches open and the transformer grounded on all sides.
  4. Press OFF test button.
  5. Ensure that the transformer's circuit breaker is open.  
⇒ Active protection test

### 4.1.5 Checking pressure monitoring device

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. Remove the cover cap.
5. Activate the sensor on the snap-action switch.  
⇒ Sensor is in the OFF position.
6. Leave the transformer's danger zone.



7. Ensure that the transformer's circuit breaker cannot be closed.
  - ⇒ Passive protection test
8. Activate the sensor on the snap-action switch.
  - ⇒ Sensor is in the OPERATION position.
9. Leave the transformer's danger zone.
10. Close the transformer's circuit breaker with isolating switches open and the transformer grounded on all sides.
11. Activate the sensor on the snap-action switch.
  - ⇒ Sensor is in the OFF position.
12. Ensure that the transformer's circuit breaker is open.
  - ⇒ Active protection test.
13. Activate the sensor on the snap-action switch to reset the pressure monitoring device.
  - ⇒ Sensor is in the OPERATION position.
14. Secure the cover cap.

### 4.1.6 Commissioning the transformer

- ✓ The signaling contact for falling below the minimum insulating fluid fill 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 inrush current impulse has subsided.

## 5 Operation

### 5.1 Operating the motor-drive unit with the hand crank

#### ▲ WARNING



#### Danger of explosion!

Unauthorized operation of the motor-drive unit with the hand crank may result in death or serious injury.

- ▶ Never operate the motor-drive unit electrically or with the hand crank before the transformer has been disconnected if you think there may be a fault in the transformer or on-load tap-changer / de-energized tap-changer.
- ▶ Never use the hand crank to complete a tap-change operation that has begun electrically, but has not been ended completely.
- ▶ If the hand crank is difficult to move, you must stop using it.
- ▶ When operating the motor-drive unit with the hand crank, never reverse the direction of rotation.
- ▶ If there is any doubt about the on-load tap-changer / de-energized tap-changer being in proper working condition or about the cause of a fault in the motor-drive unit, contact the Technical Service department of Maschinenfabrik Reinhausen GmbH immediately.
- ▶ To operate the motor-drive unit manually, only use the hand crank mounted in the motor-drive unit.

For information about fault rectification, refer to the "Fault elimination" chapter.

#### Normal operation

During normal operation, there is no need to operate the unit with the hand crank. The hand crank is mainly required during installation and for tests in the transformer plant.

Use of the hand crank for operating the motor-drive unit is permitted if the transformer is disconnected, e.g. for maintenance tasks, if there is no detectable fault on the transformer or on-load tap-changer / de-energized tap-changer and the previous tap-change operation has been completed correctly.

#### Emergency operation exception

An operation is considered an emergency operation if a tap-change operation is absolutely necessary when a transformer is energized, despite a fault in the motor-drive unit. In this case, be sure to observe the warnings listed above.



### Operating the motor-drive unit with the hand crank

To carry out a tap-change operation with the hand crank, proceed as follows:

1. Open the door of the protective housing for the motor-drive unit.
2. Switch off motor protective switch Q1 (position 0).
3. Insert the hand crank mounted in the motor-drive unit into the hand crank aperture in the upper cover plate.
  - ⇒ The built-in hand crank interlock switch interrupts the motor circuit at two poles. The control circuit will not be interrupted.
4. **NOTICE!** Damage to the on-load tap-changer due to tap-change operation not being completed correctly. Turn the hand crank in one direction until the pointer has fully circled the tap-change indicator once and is again in the mid-position of the area marked in gray on the tap-change indicator.
  - ⇒ The tap-change operation is complete.
5. Remove the hand crank and return it to the mounting bracket.
6. Switch on motor protective switch Q1 (position I).
7. Close the door of the protective housing for the motor-drive unit.



## 6 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, remedying faults.

For more information, please consult the operating instructions for the protective relay or the relevant protective device.

In the event of faults on the on-load tap-changer and motor-drive unit which cannot be easily corrected on site, or if the protective relay or additional protective devices have been tripped, please inform your authorized MR representative, the transformer manufacturer or contact MR directly.

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 93025 Regensburg



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 E-mail: service@reinhausen.com  
 Internet: www.reinhausen.com

| Fault description  | Action   |
|--|--|
| Tripping of protective relay   | See "Tripping the protective relay and re-commissioning the transformer"<br>Also contact MR.   |
| Tripping of pressure relief device (e.g. MPreC®)   | On-load tap-changer and transformer must be checked. Depending on the cause of tripping, take measurements / carry out checks on the transformer.<br>Contact MR to check the on-load tap-changer.  |
| Tripping of pressure monitoring device (e.g. DW 2000)  | See "Tripping the pressure monitoring device and putting the transformer back into operation"<br>Also contact MR.  |
| Activation of tap-change supervisory device  | 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.<br>On-load tap-changer and transformer must be checked. Depending on the cause of tripping, take measurements / carry out checks on the transformer.<br>Contact MR to check the on-load tap-changer. |
| Activation of rupture disk in on-load tap-changer head cover   | On-load tap-changer and transformer must be checked. Depending on the cause of tripping, take measurements / carry out checks on the transformer.<br>Contact MR to check the on-load tap-changer.  |
| Tripping of motor protective switch in motor-drive unit  | See chapter "Fault elimination" in the operating instructions of the TAPMOTION® ED motor-drive unit  |
| Tripping of signaling contact that indicates that the fill level of the insulating fluid has fallen below the minimum in the on-load tap-changer oil conservator | 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 the oil compartment 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.  |
| On-load tap-changer not changing tap position (sluggishness, Raise keys / Lower keys not working, no audible diverter switch action)                             | Contact MR.  |
| No change in voltage on transformer despite change in position on motor-drive unit   | Contact MR.  |
| Tap position indicator on motor-drive unit and on-load tap-changer different   | Contact MR.  |
| Noises on drive shaft or motor-drive unit when changing tap position   | 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.   |

| Fault description   | Action  |
|---|---|
| Red message on monitoring unit  | If possible read out database and send to MR along with error code.                       |
| Warning or tripping of Buchholz relay on transformer                          | Notify manufacturer of transformer.   |
| Deviation from desired value when measuring winding resistance of transformer | Contact manufacturer of transformer and, if necessary, MR, and provide measured values.   |
| Deviation from desired value during dissolved gas analysis (transformer oil)  | Contact manufacturer of transformer and, if necessary, MR, and provide measured values.   |
| Deviation from desired value during transformer ratio test                    | Contact manufacturer of transformer and, if necessary, MR, and provide measured values.   |
| Deviation from limit value for insulating fluids                              | Carry out insulating fluid change, check oil conservator breather of on-load tap-changer. |

Table 4: Fault elimination

### 6.1 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.

### 6.1.1 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.

### 6.1.2 Flap valve in OFF position



Note that protective relay RS 2004 features an automatic reset mechanism which means that the flap valve does not remain in the OFF position after tripping. If the protective relay RS 2004 has not tripped due to an error in the tripping circuit, also proceed as described below for RS 2004.

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.

### 6.1.3 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 4.1.4.1, Page 36].
2. Commission the transformer.



## 6.2 Tripping the pressure monitoring device and putting the transformer back into operation

### ▲ 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 after the pressure monitoring device has been tripped.
- ▶ Only use the equipment again when you are sure there is no damage to the on-load tap-changer or transformer.

If the circuit breaker is tripped by the pressure monitoring device, 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 pressure monitoring device sensor is in the OFF position or OPERATION position.

### 6.2.1 Sensor in the OPERATION position

If the sensor is in the OPERATION position, there may be an error in the tripping circuit. Check the tripping circuit in this case. If you are not able to clarify why the pressure monitoring device tripped, be sure to contact Maschinenfabrik Reinhausen to check the on-load tap-changer.



### 6.2.2 Sensor in the OFF position

Proceed as follows if the sensor is in the OFF position.

1. Ensure that the transformer is not started up under any circumstances.
2. Contact and inform Maschinenfabrik Reinhausen of the following:
  - ⇒ What was the load of the transformer at the instant of tripping?
  - ⇒ Was there a tap-change operation on the on-load tap-changer immediately before or during the 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?
  - ⇒ How high is the static pressure on the pressure relief device (height difference between the oil level in the on-load tap-changer oil conservator and the pressure relief device)?
3. Take further action in agreement with Maschinenfabrik Reinhausen.

### 6.2.3 Re-commissioning the transformer

You can re-commission the transformer once the cause for tripping the pressure monitoring device has been determined and resolved:

1. Ensure that the sensor on the snap-action switch is in the OPERATION position.
2. Commission the transformer.

## 7 Maintenance

### ⚠ DANGER



#### Electric shock!

An energized transformer could cause death or serious injuries.

- ▶ Switch off transformer on high and low-voltage side.
- ▶ Lock transformer to prevent unintentional restart.
- ▶ Ensure that everything is de-energized.
- ▶ Visibly connect all transformer terminals to ground (grounding leads, grounding disconnectors) and short circuit them.
- ▶ Cover or cordon off adjacent energized parts.

### ⚠ DANGER



#### Electric shock!

Working on the on-load tap-changer when on-load tap-changer components are energized can lead to death or serious injuries.

- ▶ De-energize all auxiliary circuits, such as the tap-change supervisory device, pressure relief device, pressure monitoring device.
- ▶ Make sure that everything is de-energized.

### ⚠ WARNING



#### Danger of explosion!

Explosive gases in the oil compartment of the on-load tap-changer, transformer, pipe 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 flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the transformer's immediate surroundings 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.

### 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.



## 7.1 Inspection

Monitoring the on-load tap-changer and motor-drive unit/control cabinet is limited to occasional visual checks and monitoring the quality of the insulating fluid. For efficiency reasons these visual inspections can be combined with the usual checks on the transformer.

| Interval      | Action  |
|---------------|---|
| Annually      | Check the door seal, cable bushings, and ventilation of the motor-drive unit/control cabinet housing.   |
| Annually      | Check the sealing points of the on-load tap-changer head, the protective relay, and the connected pipes.  |
| Annually      | Check the correct function of the installed electrical heater in the motor-drive unit/control cabinet housing.  |
| Annually      | Check the correct function of the protective relay [► Section 4.1.4, Page 36].  |
| Annually      | Check the perfect condition of the breather (silica gel) for the on-load tap-changer oil conservator.   |
| Every 2 years | <p>Check the quality of the insulating fluid of on-load tap-changers that are installed in positions other than the neutral point of windings (Class 2 in accordance with ICE 60214-1).</p> <ol style="list-style-type: none"><li>1. Take a sample of insulating fluid from the oil compartment.</li><li>2. Record the temperature of the sample (insulating fluid) immediately after the sample is taken.</li><li>3. Determine the dielectric strength and water content at an insulating fluid temperature of <math>20^{\circ}\text{C} \pm 5^{\circ}\text{C}</math>. The dielectric strength and water content must comply with the limit values specified in the technical data.</li><li>4. If the limit values are not complied with, change the insulating fluid in accordance with the "Changing the insulating fluid" section.</li></ol> |
| Every 7 years | <p>Check the quality of the insulating fluid of on-load tap-changers that are installed at the neutral point of windings (Class 1 in accordance with IEC 60214-1).</p> <ol style="list-style-type: none"><li>1. Take a sample of insulating fluid from the oil compartment.</li><li>2. Record the temperature of the sample (insulating fluid) immediately after the sample is taken.</li><li>3. Determine the dielectric strength and water content at an insulating fluid temperature of <math>20^{\circ}\text{C} \pm 5^{\circ}\text{C}</math>. The dielectric strength and water content must comply with the limit values specified in the technical data.</li><li>4. If the limit values are not complied with, change the insulating fluid in accordance with the "Changing the insulating fluid" section.</li></ol>                      |

Table 5: Inspection plan



## 7.2 Maintenance intervals

### Maintenance intervals without MR monitoring system

**⚠ WARNING**



#### Danger of explosion!

If pending maintenance work is not carried out immediately, this may lead to death or serious injury as a result of a progressive short circuit, for example.

► Adherence to the following maintenance intervals is mandatory.

If you are operating the on-load tap-changer without an MR monitoring system, the following maintenance intervals shall apply.

#### Maintenance intervals of the selector

After 1 million tap-change operations (motor-drive unit counter reading), contact Maschinenfabrik Reinhausen Technical Service.

#### Maintenance intervals of diverter switch insert

The diverter switch insert must be replaced after 800,000 tap change operations.

#### Maintenance intervals for single-phase on-load tap-changers which are used as follows:

- in neutral point application
- in auto transformers with  $U_m < 245$  kV
- in winding with delta connection with  $U_m < 245$  kV
- for regulation at the transformer's winding line end with  $U_m < 245$  kV

**First maintenance** After every 7 years, or after the number of tap-change operations stated in the following table, whichever is reached first.

**Further maintenance** After every 7 years, or after the number of tap-change operations stated in the following table, whichever is reached first.

| On-load tap-changer | Rated transformer current | Number of tap-change operations |                         |
|---------------------|---------------------------|---------------------------------|-------------------------|
|                     |                           | Without MR oil filter unit      | With MR oil filter unit |
| R I 1201-RC/RD/RDE  | up to 600 A               | 80,000                          | 100,000                 |
|                     | up to 1,200 A             | 60,000                          | 100,000                 |
| R I 2002-RC/RD/RDE  | up to 2,000 A             | 40,000                          | 80,000                  |
| R I 2402-RC/RD/RDE  | up to 2,400 A             | 40,000                          | 80,000                  |
| R I 3003-RC/RD/RDE  | up to 3,000 A             | 40,000                          | 80,000                  |

Table 6: Maintenance intervals



**Maintenance intervals for single-phase on-load tap-changers which are used as follows:**

- in auto transformers with  $U_m \geq 245$  kV
- in winding with delta connection with  $U_m \geq 245$  kV
- for regulation at the transformer's winding line end with  $U_m \geq 245$  kV

**First maintenance** After 2 years or 20,000 tap-change operations, whichever is reached first.

**Further maintenance** After every 4 years without MR oil filter unit, after every 6 years with MR oil filter unit, or after the number of tap-change operations indicated in the following table – whichever is reached first.

| On-load tap-changer | Rated transformer current | Number of tap-change operations |                         |
|---------------------|---------------------------|---------------------------------|-------------------------|
|                     |                           | Without MR oil filter unit      | With MR oil filter unit |
| R I 1201-RC/RD/RDE  | up to 600 A               | 40,000                          | 50,000                  |
|                     | up to 1,200 A             | 30,000                          | 50,000                  |
| R I 2002-RC/RD/RDE  | up to 2,000 A             | 20,000                          | 40,000                  |
| R I 2402-RC/RD/RDE  | up to 2,400 A             | 20,000                          | 40,000                  |
| R I 3003-RC/RD/RDE  | up to 3,000 A             | 20,000                          | 40,000                  |

Table 7: Maintenance intervals

**Maintenance intervals for three-phase on-load tap-changers in neutral point applications**

**First maintenance** After every 7 years, or after the number of tap-change operations stated in the following table, whichever is reached first.

**Further maintenance** After every 7 years, or after the number of tap-change operations stated in the following table, whichever is reached first.

| On-load tap-changer    | Rated transformer current | Number of tap-change operations |                         |
|------------------------|---------------------------|---------------------------------|-------------------------|
|                        |                           | Without MR oil filter unit      | With MR oil filter unit |
| R III 1200 Y-RC/RD/RDE | up to 600 A               | 80,000                          | 100,000                 |
|                        | up to 1,200 A             | 60,000                          | 100,000                 |

Table 8: Maintenance intervals



A label on the inside of the door of the TAPMOTION® ED motor-drive unit also specifies the relevant maintenance interval.

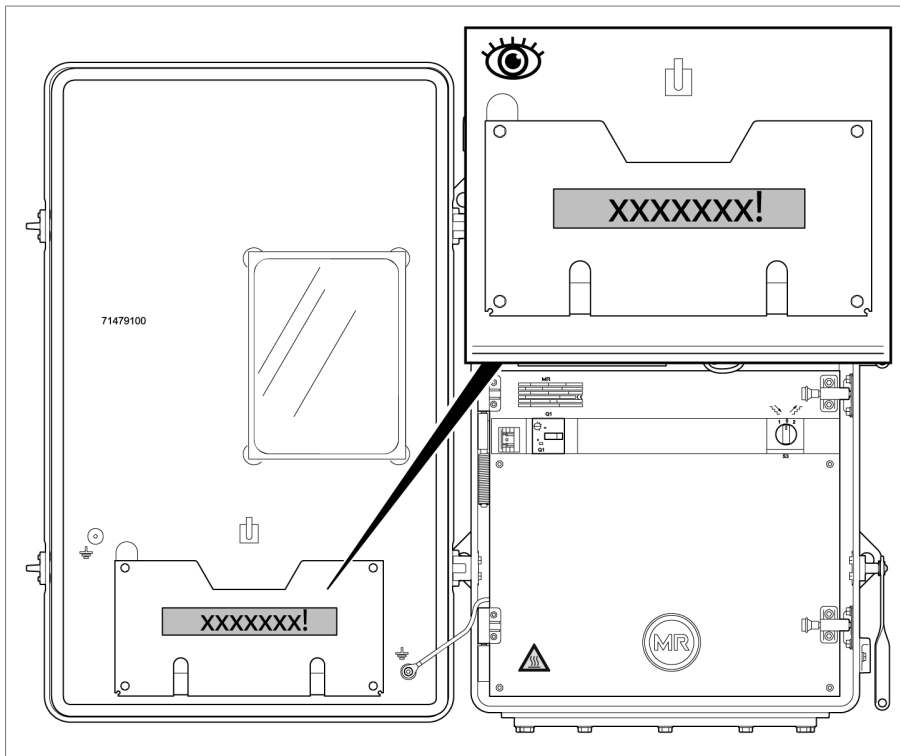


Figure 21: Label showing maintenance intervals

**Maintenance intervals with MR monitoring system**

**▲ WARNING**



**Danger of explosion!**

If pending maintenance work is not carried out immediately, this may lead to death or serious injury as a result of a progressive short circuit, for example.

- ▶ Contact the Maschinenfabrik Reinhausen GmbH Technical Service department as soon as the MR monitoring system issues a maintenance warning.
- ▶ In the event of failure or shutdown of the MR monitoring system, observe the maintenance intervals as specified in the maintenance plan without the MR monitoring system.

If you are operating the on-load tap-changer with an MR monitoring system, the maintenance intervals displayed by the MR monitoring system shall apply.

More information can be found in the operating instructions for the MR monitoring system.

### 7.3 Oil change

**NOTICE**

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

Unsuitable insulating fluids cause damage to the on-load tap-changer.

- ▶ Only use insulating fluids [▶ Section 8.1, Page 53] approved by the manufacturer.
- ▶ Ensure that the new insulating fluid has the same chemical, mechanical, thermal and electrical properties. Otherwise, contact Maschinenfabrik Reinhausen GmbH's Technical Service department.

The dielectric strength and water content of the insulating fluid must be determined after filling. Proceed as follows:

1. Take an insulating fluid sample from the oil compartment.
2. Record the temperature of the sample immediately after the sample is taken.
3. Determine dielectric strength and water content at a diverter switch oil temperature of  $20\text{ °C} \pm 5\text{ °C}$ . The dielectric strength and water content must comply with the limit values [▶ Section 8.5, Page 59] specified in the technical data.

### 7.4 Performing DC resistance measurement on 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.

| Status of oil compartment                    | Without interruption in measured current | With interruption (measured current = 0 A before change of operating position) |
|--|--|--|
| Oil compartment empty                        | Maximum 10 A DC                          | Maximum 50 A DC  |
| Oil compartment filled with insulating fluid | Maximum 50 A DC                          | Maximum 50 A DC  |

Table 9: Maximum permitted measured currents when performing DC resistance measurement on 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 Permissible ambient conditions

|  |   |
|--|---|
| Air temperature during operation                 | -25°C...+50°C   |
| Temperature of the insulating fluid in operation | -25°C...+105°C (up to +115°C when the transformer is in emergency operation)  |
| Transport temperature, storage temperature       | -40°C...+50°C   |
| Drying temperatures                              | See installation and commissioning instructions, "Mounting" chapter   |
| Compressive strength                             | See technical data TD 61 – General section  |
| Insulating fluid                                 | <ul style="list-style-type: none"> <li>▪ Unused insulating oils derived from petroleum products<sup>1)</sup> in accordance with IEC60296 and ASTM D3487 (equivalent standards on request)</li> <li>▪ Unused insulating oils derived from other virgin hydrocarbons in accordance with IEC60296, or blends of these oils with petroleum products<sup>1)</sup> in accordance with IEC60296, ASTM D3487 or equivalent standards on request</li> <li>▪ Alternative insulating fluids, such as natural and synthetic esters or silicone oils, on request.</li> </ul> <p><sup>1)</sup> Gas-to-liquid oils (GTL oils) are understood in this context as petroleum products</p> |
| 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

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

|   |                          |
|---|--------------------------|
| Housing   | Outdoor model            |
| Degree of protection  | IP66                     |
| Relay actuation   | Flap valve with aperture |
| Weight  | approx. 3.5 kg           |
| 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 ± 0.40 m/s          |
|   | 4.80 ± 0.60 m/s          |

Table 11: General technical data



### Tripping circuit

The protective relay can be supplied with either a normally open (NO) or a normally closed (NC) dry-reed magnetic switch (see dimensional drawing supplied). Other contact combinations are available as a special version.

### Electrical data for normally closed (NC) dry-reed magnetic switch

| Electrical data               |                 |
|-------------------------------|-----------------|
| DC switching capacity         | 1.2 W...200 W   |
| AC switching capacity (50 Hz) | 1.2 VA...400 VA |
| Switching voltage AC/DC       | 24 V...250 V    |
| Switched current AC/DC        | 4.8 mA...2 A    |

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 $\cos \varphi = 0.6$ )   |
| Maximum switched current AC (highest voltage)    | 1.6 A (at 250 V with $\cos \varphi = 0.6$ ) |
| 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               |                 |
|-------------------------------|-----------------|
| DC switching capacity         | 1.2 W...250 W   |
| AC switching capacity (50 Hz) | 1.2 VA...400 VA |
| Switching voltage AC/DC       | 24 V...250 V    |
| Switched current AC/DC        | 4.8 mA...2 A    |

Table 15: 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)    | 2 A (at 125 V with L/R = 40 ms)             |
| Maximum switched current DC (highest voltage)    | 1 A (at 250 V with L/R = 40 ms)             |
| Maximum switched current AC (highest current)    | 2 A (at 125 V with $\cos \varphi = 0.6$ )   |
| Maximum switched current AC (highest voltage)    | 1.6 A (at 250 V with $\cos \varphi = 0.6$ ) |
| Switching operations                             | 1,000 cycles                                |

Table 16: 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 17: Dielectric strength

### Ambient conditions

|                           |  |
|---------------------------|--|
| Ambient temperature $T_a$ | -40°C...+50°C                                |
| Oil temperature           | <130 °C                                      |
| Air pressure              | Corresponds to 0 m...4,000 m above sea level |

Table 18: Ambient conditions

### 8.3 Special models of protective relay

#### 8.3.1 Protective relay with CO change-over contact as tripping switch

The protective relay can be supplied with a dry-reed magnetic switch, CO change-over (variant 3) (see dimensional drawing supplied).

##### Electrical data for CO change-over dry-reed magnetic switch

| Electrical data               |                 |
|-------------------------------|-----------------|
| DC switching capacity         | 1.2 W...150 W   |
| AC switching capacity (50 Hz) | 1.2 VA...200 VA |
| Switching voltage AC/DC       | 24 V...250 V    |
| Switched current AC/DC        | 4.8 mA...1 A    |

Table 19: 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)    | 1.0 A (at 150 V with L/R = 40 ms)           |
| Maximum switched current DC (highest voltage)    | 0.6 A (at 250 V with L/R = 40 ms)           |
| Maximum switched current AC (highest current)    | 1 A (at 200 V with $\cos \varphi = 0.6$ )   |
| Maximum switched current AC (highest voltage)    | 0.8 A (at 250 V with $\cos \varphi = 0.6$ ) |
| Switching operations                             | 1,000 cycles                                |

Table 20: 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                                     | 1,150 V, 50 Hz, test duration 1 minute |

Table 21: Dielectric strength



### 8.3.2 Protective relay with several dry-reed magnetic switches

The protective relay can be 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 (see dimensional drawing supplied).

Electrical data for normally open (NO) and normally closed (NC) dry-reed magnetic switch



## 8.4 Technical data for pressure monitoring device

### General technical data

|  |  |
|--|--|
| Setup  | Outdoor model  |
| Ambient temperature                          | -40 °C...+80 °C (mechanical)   |
| Cable gland                                  | M25x1.5  |
| Degree of protection                         | IP55 in accordance with IEC 60529 (enclosed device)                        |
| Relay actuation                              | Corrugated tubing with counter-pressure spring                             |
| Oil temperature                              | -40 °C...+100 °C   |
| Weight                                       | approx. 1.2 kg   |
| Equipment                                    | For standard insulating fluids (IEC60296 and IEC60422)                     |
| Sealing material (oil – air)                 | VITON  |
| Permitted pressure range (absolute pressure) | 1 bar...6 bar, vacuum not permitted  |
| Upper switching pressure                     | 3.8 ± 0.2 bar (trip pressure)  |
| Lower switching pressure                     | 2,8 ± 0,2 bar  |
| <b>Snap-action switch</b>                    |  |
| Connection terminals                         | Lead connection: 1 or 2 leads per terminal (Ø 0.75...2.5 mm <sup>2</sup> ) |
| Contacts                                     | 1xNO (normally open), 1xNC (normally closed)                               |
| Utilization category                         | IEC 60947-5-1:<br>AC 15: 230 V/1 A<br>DC 13: 60 V/0.5 A                    |
| Maximum continuous current                   | 10 A   |
| Rated insulation voltage                     | AC: 2.5 kV/min   |

Table 22: General technical data



### 8.5 Limit values for dielectric strength and water content of insulating fluids

The following tables provide the limit values for dielectric strength (measured in accordance with IEC 60156) and water content (measured in accordance with IEC 60814) of insulating fluids for OILTAP® on-load tap-changers. The values have been established on the basis of IEC 60422.

| In operation  | U <sub>d</sub> | H <sub>2</sub> O |
|---|----------------|------------------|
| When commissioning the transformer for the first time | > 60 kV/2.5 mm | < 12 ppm         |
| During operation                                      | > 30 kV/2.5 mm | < 40 ppm         |
| After maintenance                                     | > 50 kV/2.5 mm | < 15 ppm         |

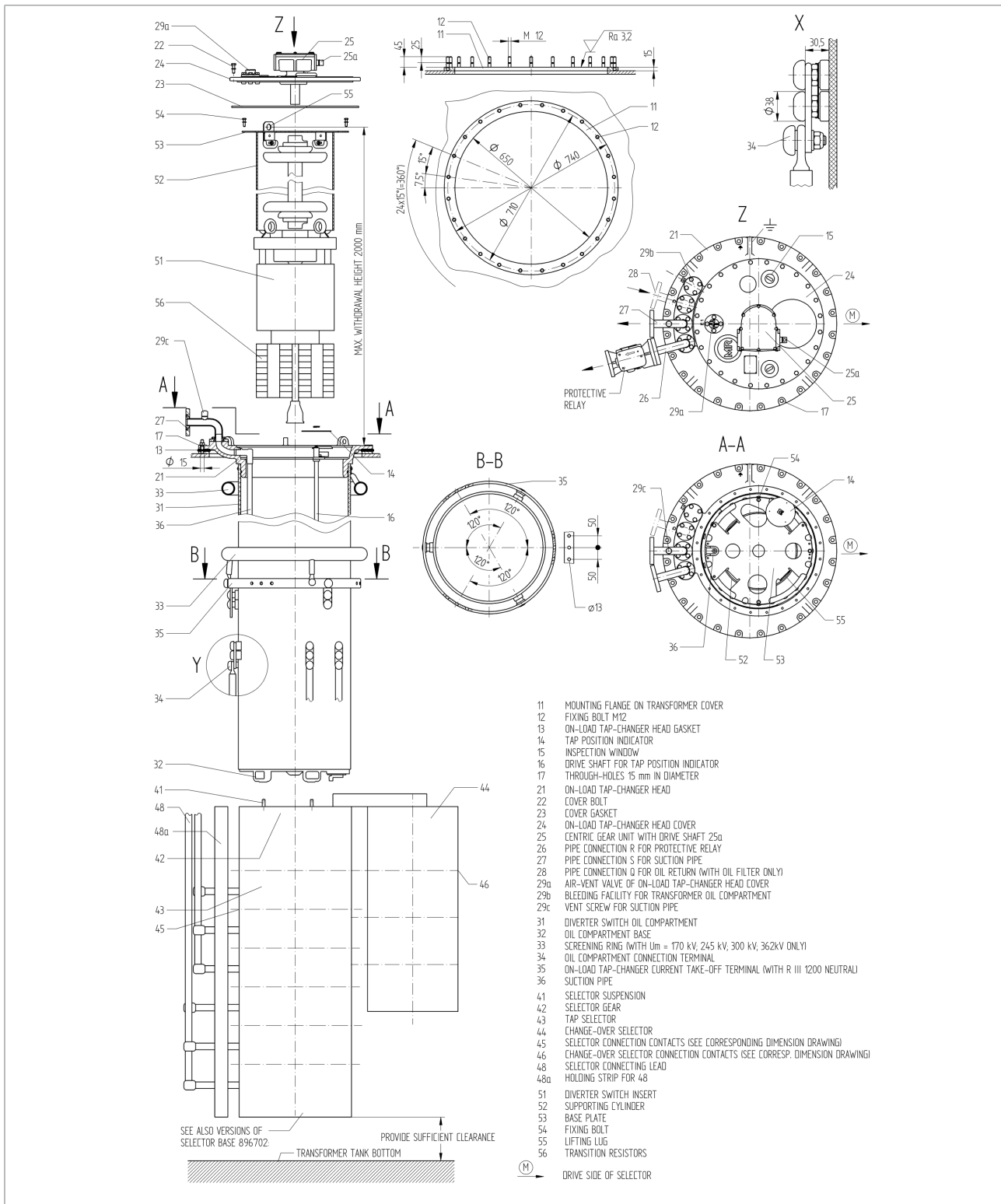
Table 23: Limit values for insulating fluids for neutral point applications

| In operation  | U <sub>d</sub> | H <sub>2</sub> O |
|---|----------------|------------------|
| When commissioning the transformer for the first time | > 60 kV/2.5 mm | < 12 ppm         |
| During operation                                      | > 40 kV/2.5 mm | < 30 ppm         |
| After maintenance                                     | > 50 kV/2.5 mm | < 15 ppm         |

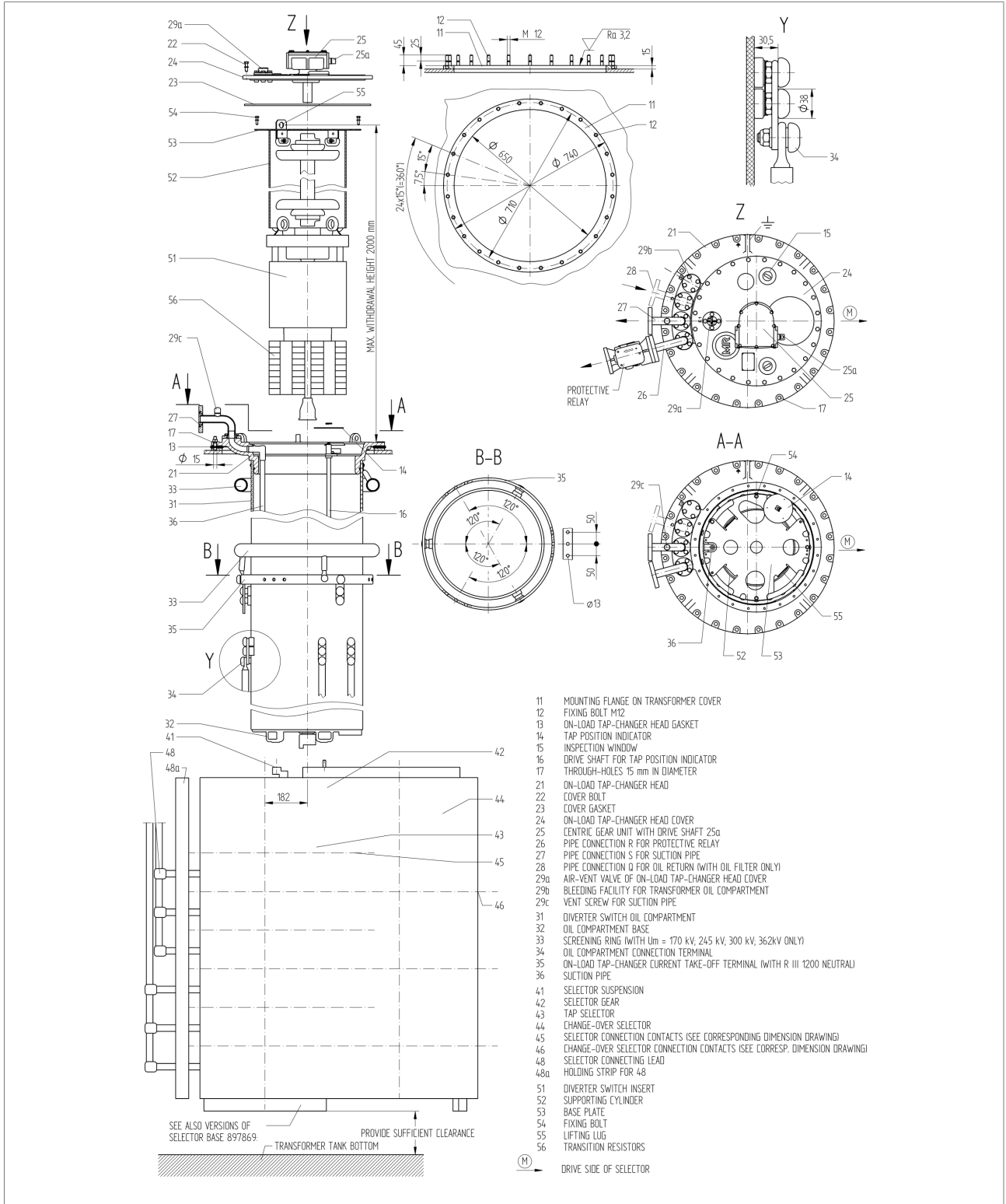
Table 24: Limit values for insulating fluids for non-neutral point applications

## 9 Drawings

### 9.1 OILTAP® R, installation drawing for selector size C/D (896705)

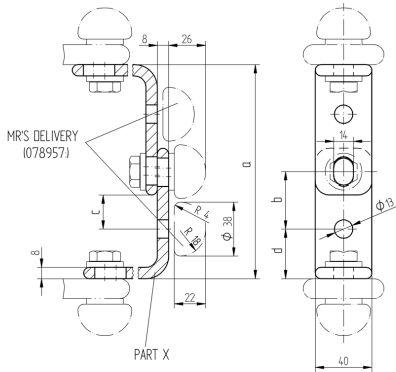


### 9.2 OILTAP® R, installation drawing for selector size E (897873)

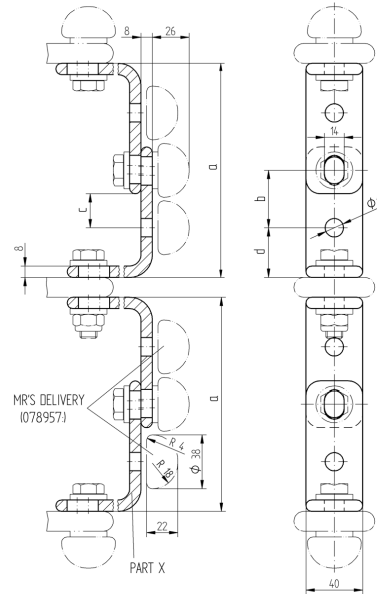


### 9.3 OILTAP® R, R I 2002/2003-C/D, R I 3003-C/D, bridges for parallel connection of selector plane (896706)

R I 2002 / 2003 SELECTOR SIZE C / D 1 : 15  
2 SELECTOR CONTACT PLANES IN PARALLEL



R I 3003 SELECTOR SIZE C / D 1 : 15  
3 SELECTOR CONTACT PLANES IN PARALLEL



REQUIRED PARALLEL BRIDGES ON ON-LOAD TAP-CHANGERS WITHOUT CHANGE-OVER SELECTOR

| USE                      | PART X | a   | b  | c  | d  |
|--------------------------|--------|-----|----|----|----|
| IN ALL CONTACT POSITIONS | 077141 | 148 | 39 | 22 | 35 |

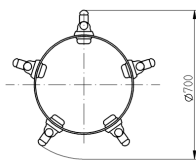
REQUIRED PARALLEL BRIDGES ON ON-LOAD TAP-CHANGERS WITH CHANGE-OVER SELECTOR

| USE  | PART X | a   | b    | c    | d  |
|--|--------|-----|------|------|----|
| TAP SELECTOR / SELECTOR SIZE C AND D / CONTACTS 1 TO n-2       | 077141 | 148 | 39   | 22   | 35 |
| TAP SELECTOR / SELECTOR SIZE C AND D / CONTACT n-1             | 097668 | 148 | 39   | 22   | 35 |
| COARSE CHANGE-OVER SELEC. / SELECTOR SIZE C / CONTACT 0 AND -  | 077196 | 183 | 46.5 | 29.5 | 45 |
| COARSE CHANGE-OVER SELEC. / SELECTOR SIZE C / CONTACT +        | 097669 | 187 | 48.5 | 31.5 | 45 |
| COARSE CHANGE-OVER SELEC. / SELECTOR SIZE D / CONTACT 0 AND -  | 077197 | 298 | 74   | 57   | 75 |
| COARSE CHANGE-OVER SELEC. / SELECTOR SIZE D / CONTACT +        | 097670 | 302 | 76   | 59   | 75 |
| REVERSING CHANGE-OVER SEL. / SELECTOR SIZE C / CONTACT + AND - | 077196 | 183 | 46.5 | 29.5 | 45 |
| REVERSING CHANGE-OVER SEL. / SELECTOR SIZE C / CONTACT 0       | 097669 | 187 | 48.5 | 31.5 | 45 |
| REVERSING CHANGE-OVER SEL. / SELECTOR SIZE D / CONTACT + AND - | 077197 | 298 | 74   | 57   | 75 |
| REVERSING CHANGE-OVER SEL. / SELECTOR SIZE D / CONTACT 0       | 097670 | 302 | 76   | 59   | 75 |

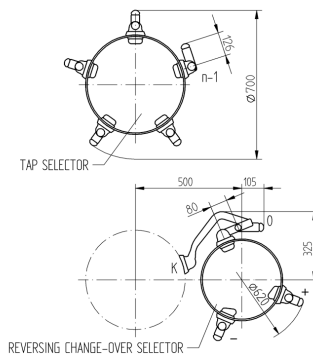
PLEASE NOTE:  
PARALLEL BRIDGES ARE NOT INCLUDED  
IN THE STANDARD DELIVERY.

ARRANGEMENT OF THE PARALLEL BRIDGES ON THE ON-LOAD TAP-CHANGER (SELECTOR PITCH 10 REPRESENTATION)

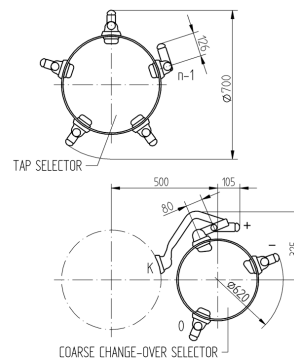
WITHOUT CHANGE-OVER SELECTOR



WITH REVERSING CHANGE-OVER SELECTOR



WITH COARSE CHANGE-OVER SELECTOR

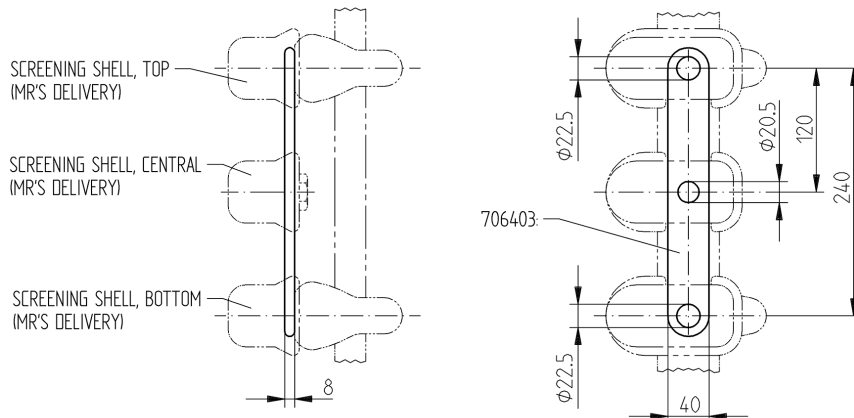




**9.4 OILTAP® R, R I 2002/2003-E, R I 3003-E, bridges for parallel connection of selector plane (898713)**

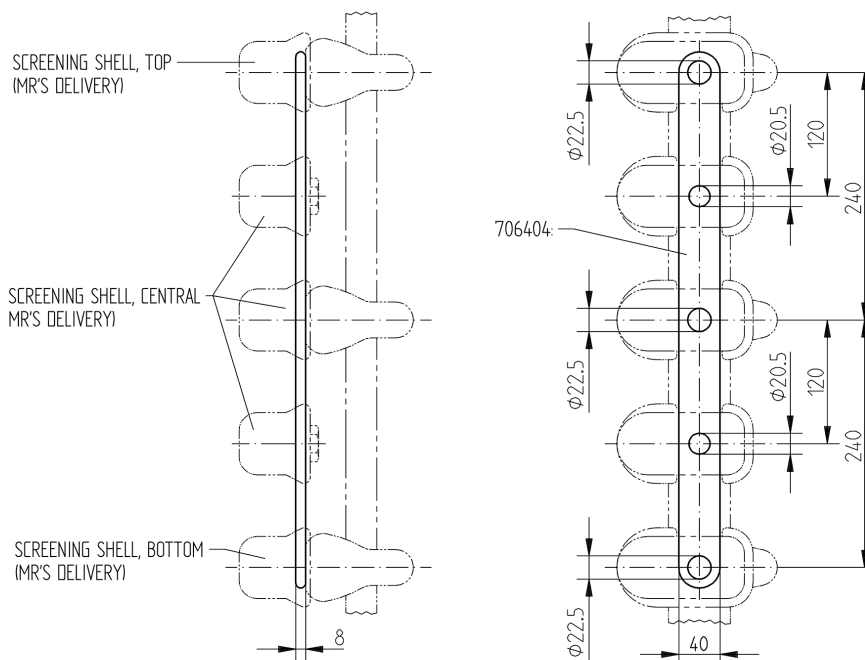
R I 2002 / 2003 SELECTOR SIZE E

2 SELECTOR CONTACT PLANES IN PARALLEL / 3 TERMINALS FOR CUSTOMER'S USE



R I 3003 SELECTOR SIZE E

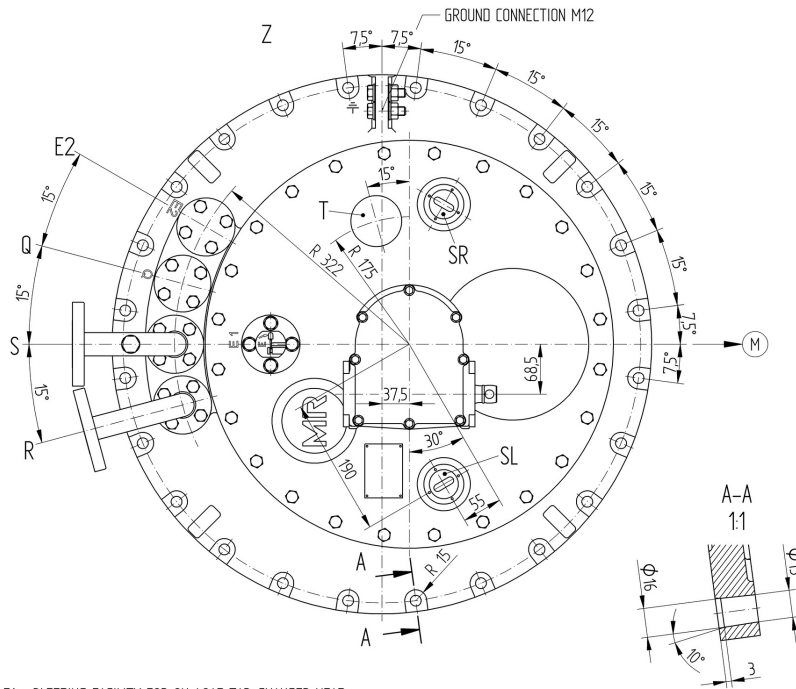
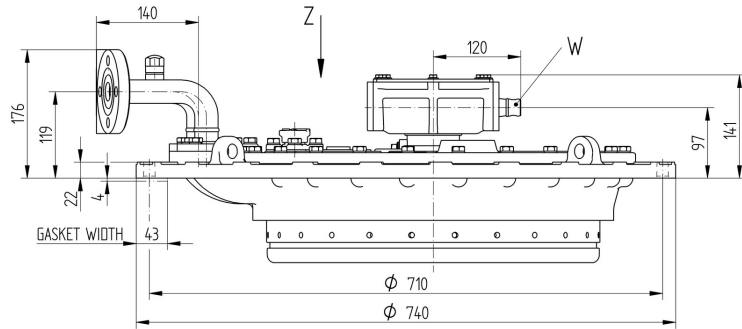
3 SELECTOR CONTACT PLANES IN PARALLEL / 5 TERMINALS FOR CUSTOMER'S USE



PLEASE NOTE: PARALLEL BRIDGES ARE NOT INCLUDED IN THE STANDARD DELIVERY.

### 9.5 OILTAP® R, on-load tap-changer head (893899)

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- 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, Q OR BLEEDER SCREW CAN BE USED)
  - Q = CONNECTION FOR OIL RETURN PIPE OR TAP-CHANGE SUPERVISORY CONTROL
  - S = CONNECTION FOR SUCTION PIPE
  - R = CONNECTION FOR PROTECTIVE RELAY (EXCHANGEABLE WITH CONNECTION Q)
  - T = THERMOMETER BAG / TEMPERATURE SENSOR (OPTIONALLY)
  - SR = INSPECTION WINDOW, RIGHT
  - SL = INSPECTION WINDOW, LEFT
  - W = DRIVE SHAFT
  - (M) DRIVE SIDE OF SELECTOR
- CONNECTIONS SWIVELING  
 DIMENSIONS AND SELECTION 899496 / 899497:

| DATE       | NAME         | DOCUMENT NO.       |
|------------|--------------|--------------------|
| 28.04.2014 | RAEULINGER   | SED 1661272 001 03 |
| 17.06.2014 | HAUER        | CHANGE NO.         |
| 17.06.2014 | PRODASTSCHUK | 1057233            |
|            |              | SCALE 1:2.5        |

DIMENSION  
 IN mm  
 EXCEPT AS  
 NOTED



ON-LOAD TAP-CHANGER  
 OILTAP® M, MS, R, RM AND VACUTAP® VR®, VM®  
 ON-LOAD TAP-CHANGER HEAD, CENTRIC DRIVE

SERIAL NUMBER

|                 |       |
|-----------------|-------|
| MATERIAL NUMBER | SHEET |
| 893899EE        | 1/1   |



9.6 OILTAP® R, flange for pressure relief device (895168)

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|            |              |                    |
|------------|--------------|--------------------|
| DATE       | NAME         | DOCUMENT NO.       |
| 28.04.2014 | RAEDLINGER   | SED 1660250 001 02 |
| 17.06.2014 | HAUER        | CHANGE NO.         |
| 17.06.2014 | PRODASTSCHUK | 1057233            |
|            |              | SCALE              |
|            |              | 1:2,5              |

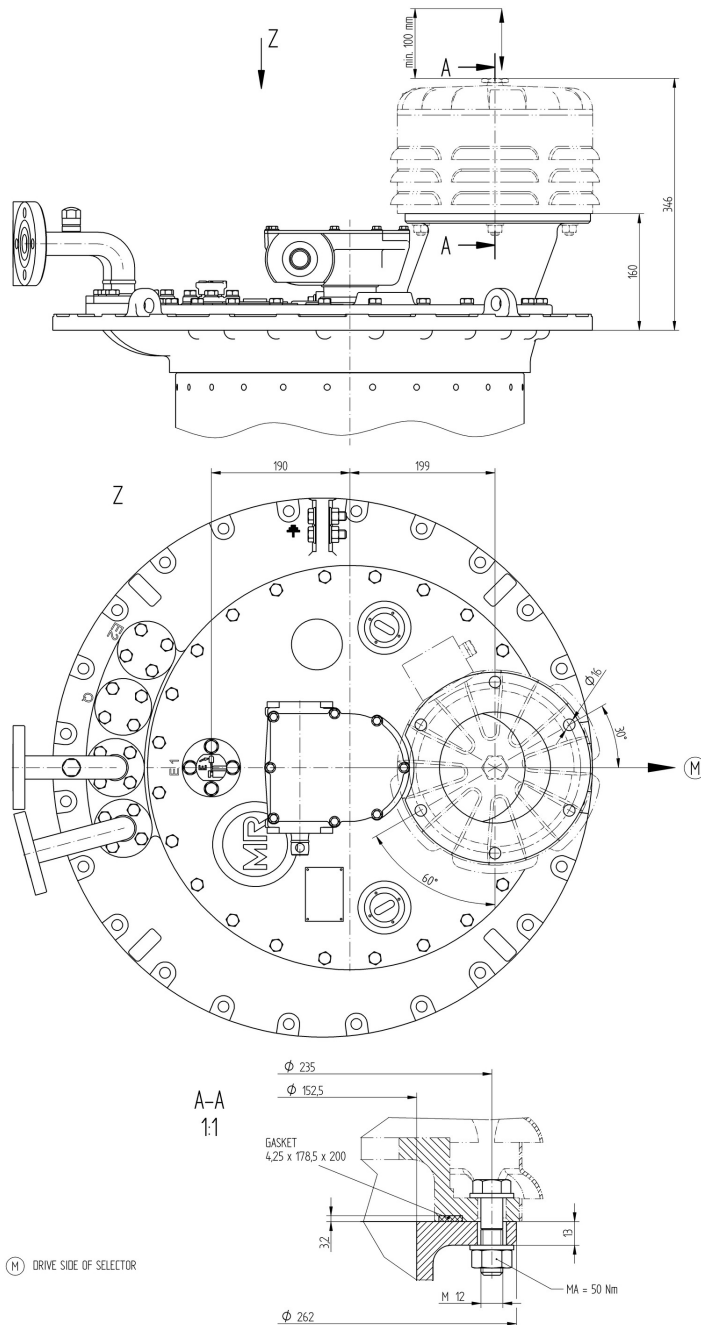
DIMENSION  
 IN mm  
 EXCEPT AS  
 NOTED



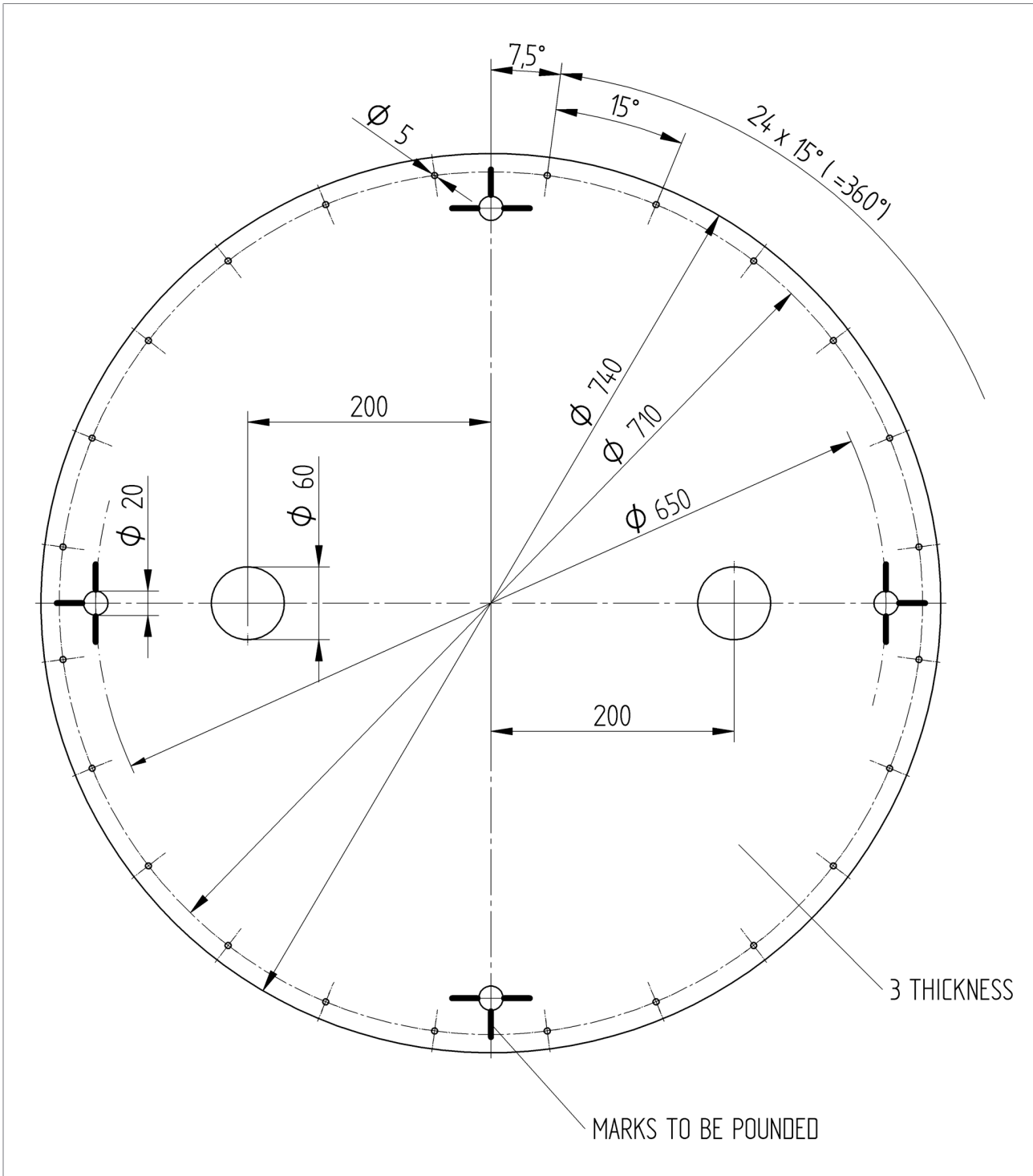
ON-LOAD TAP-CHANGER  
 OILTAP® M, MS, R, RM AND VACUTAP® VR®, VM®  
 WITH MOUNTING FLANGE FOR PRESSURE RELIEF DEVICE

SERIAL NUMBER

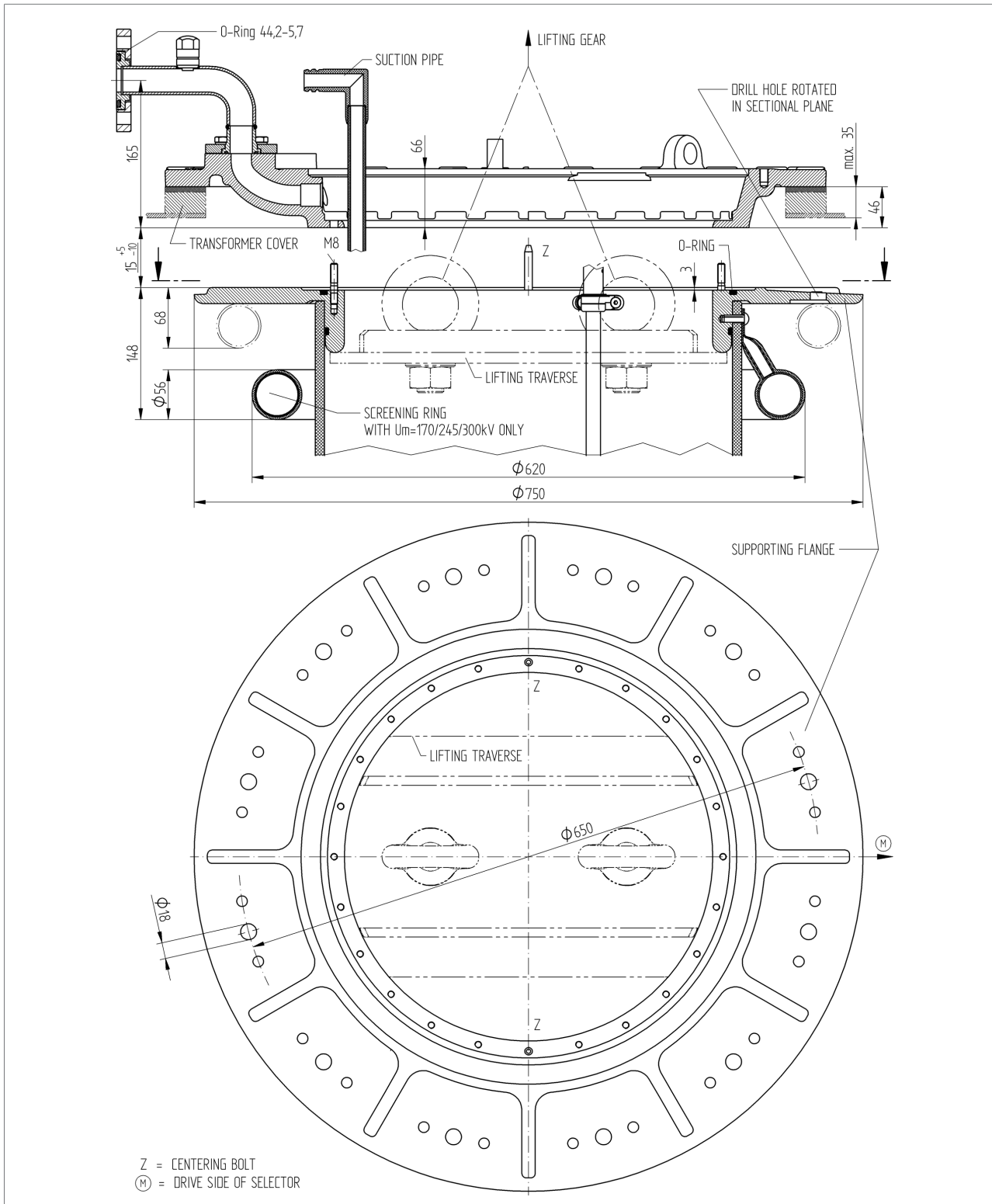
|                 |       |
|-----------------|-------|
| MATERIAL NUMBER | SHEET |
| 8951688E        | 1/1   |



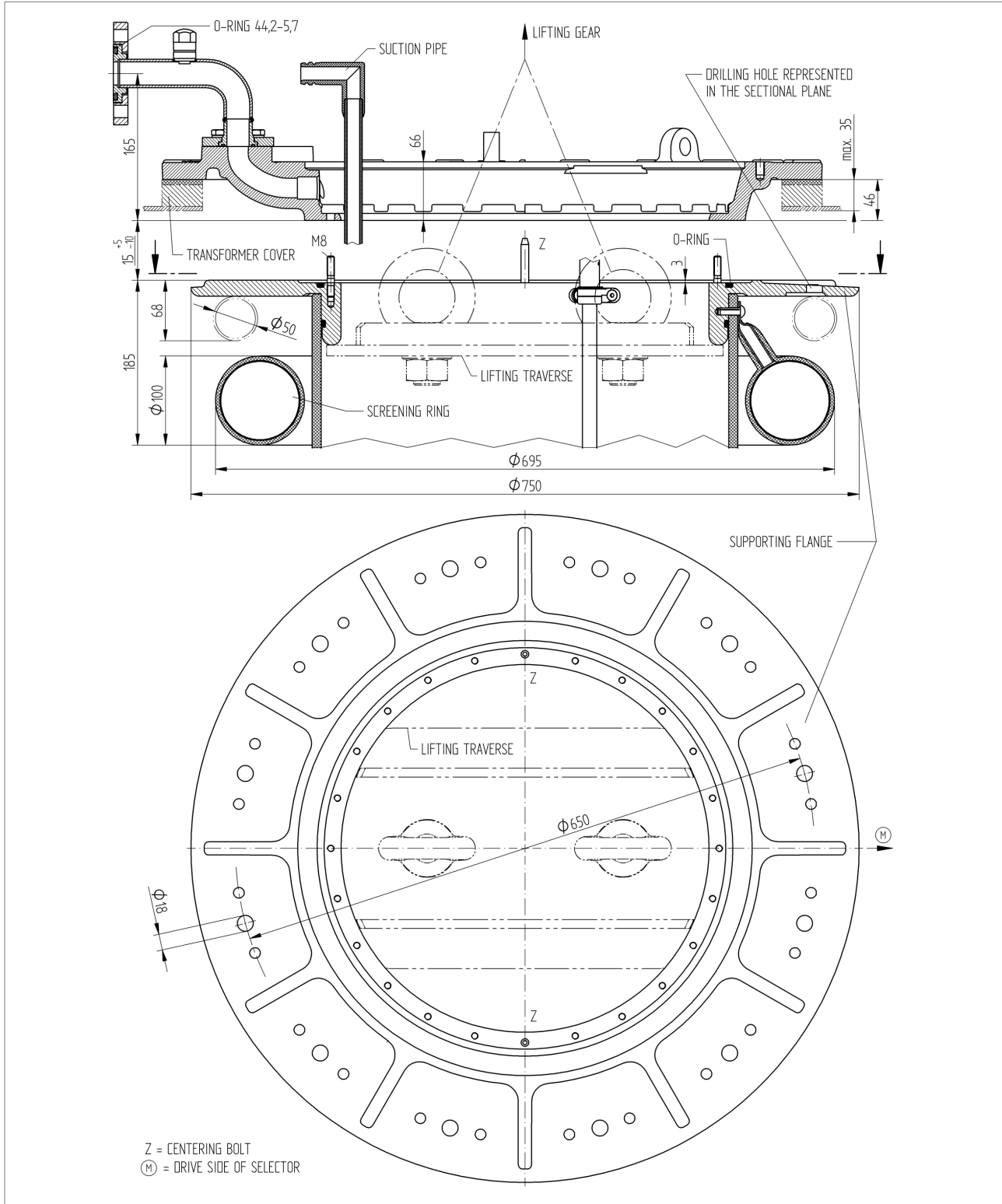
### 9.7 Tracing template for on-load tap-changer head (890183)



### 9.8 OILTAP® R, supporting flange for bell-type tank installation up to Um=300 kV (896762)



### 9.9 OILTAP® R, supporting flange for bell-type tank installation up to Um=362 kV (725912)





### 9.10 OILTAP® R, tap selector connection contacts and change-over selector connection contacts for selector size E (897868)

THE SELECTION OF STRAIGHT CABLE SHOE OR ANGLE-SHAPED BY 90° MUST BE MADE BY THE TRANSFORMER MANUFACTURER FOR EACH CONNECTION CONTACT. (FOR MODEL WITH CHANGE-OVER SELECTOR: CONTACT "n MINUS 1" ALLOWS STRAIGHT CABLE SHOE ONLY, CONTACT "K" IS NOT FOR CUSTOMER'S USE.)

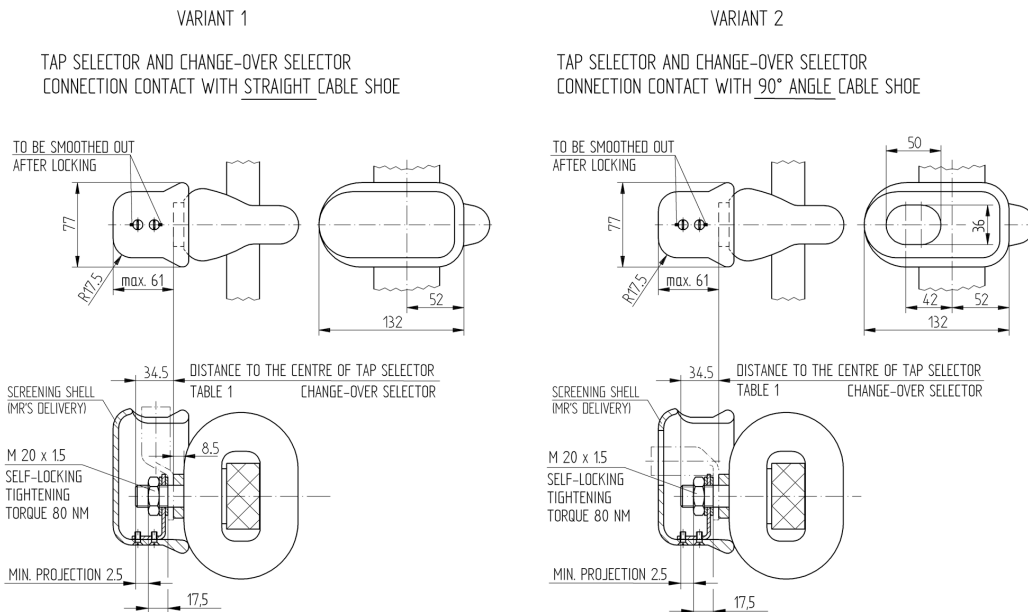
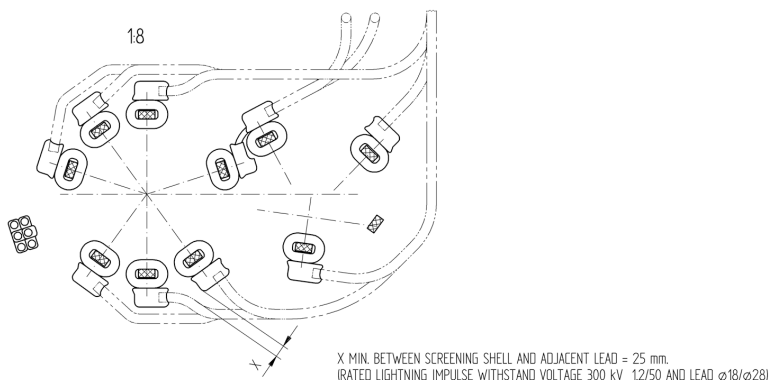


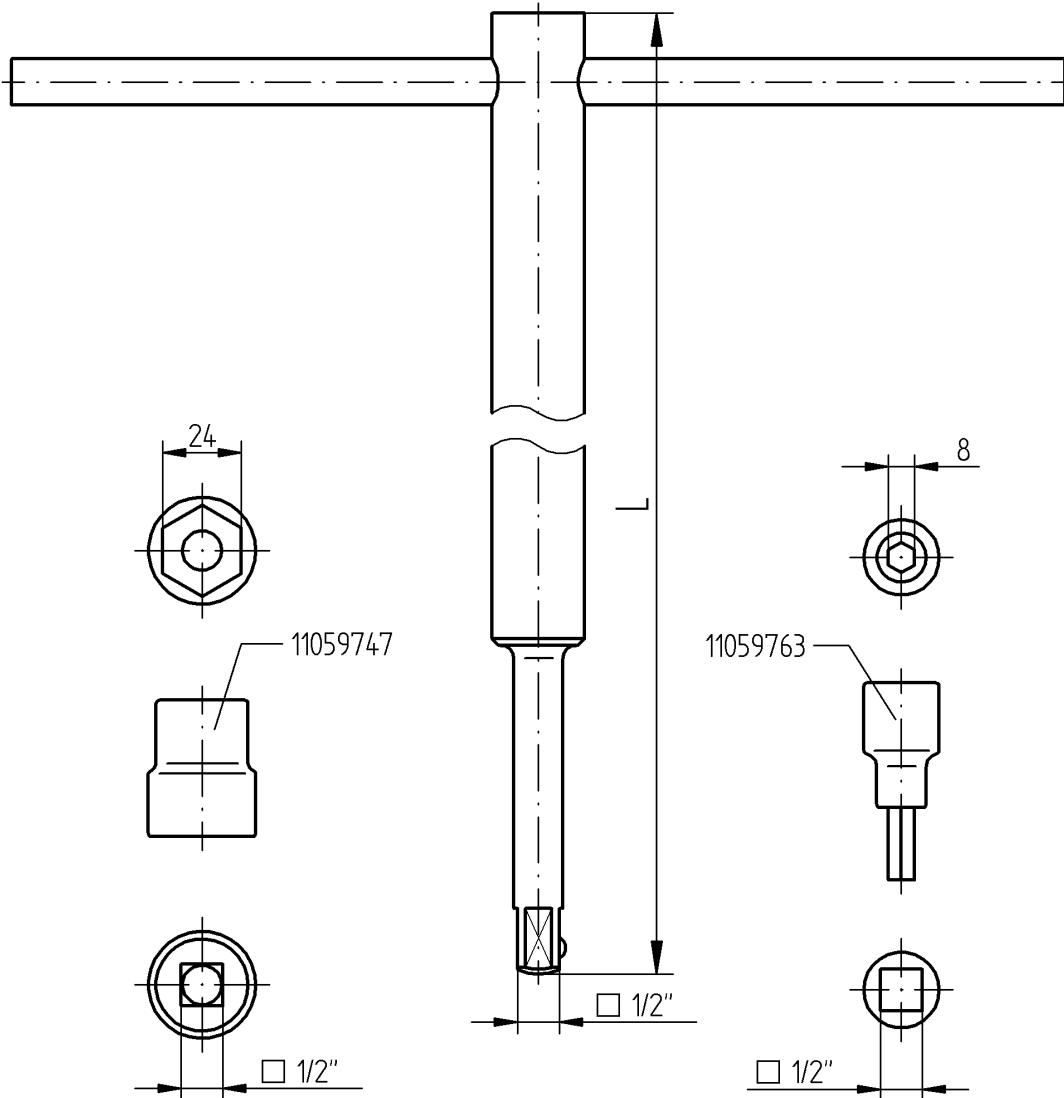
TABLE 1: DISTANCE TO THE CENTRE OF TAP SELECTOR / CHANGE-OVER SELECTOR (CONNECTING POINTS)

| DESIGNATION OF CONNECTION CONTACTS                   |     |
|--|-----|
| TAP SELECTOR CONNECTION CONTACTS                     | 352 |
| CHANGE-OVER SELECTOR CONNECTION CONTACT "0"          | 176 |
| CHANGE-OVER SELECTOR CONNECTION CONTACTS "+" AND "-" | 383 |

THE ABOVE VARIANTS ARE APPLICABLE TO ONE SELECTOR CONNECTING LEAD FOR EACH CONNECTION CONTACT. TWO SELECTOR CONNECTING LEADS FOR EACH CONNECTION CONTACTS AVAILABLE ON DEMAND.

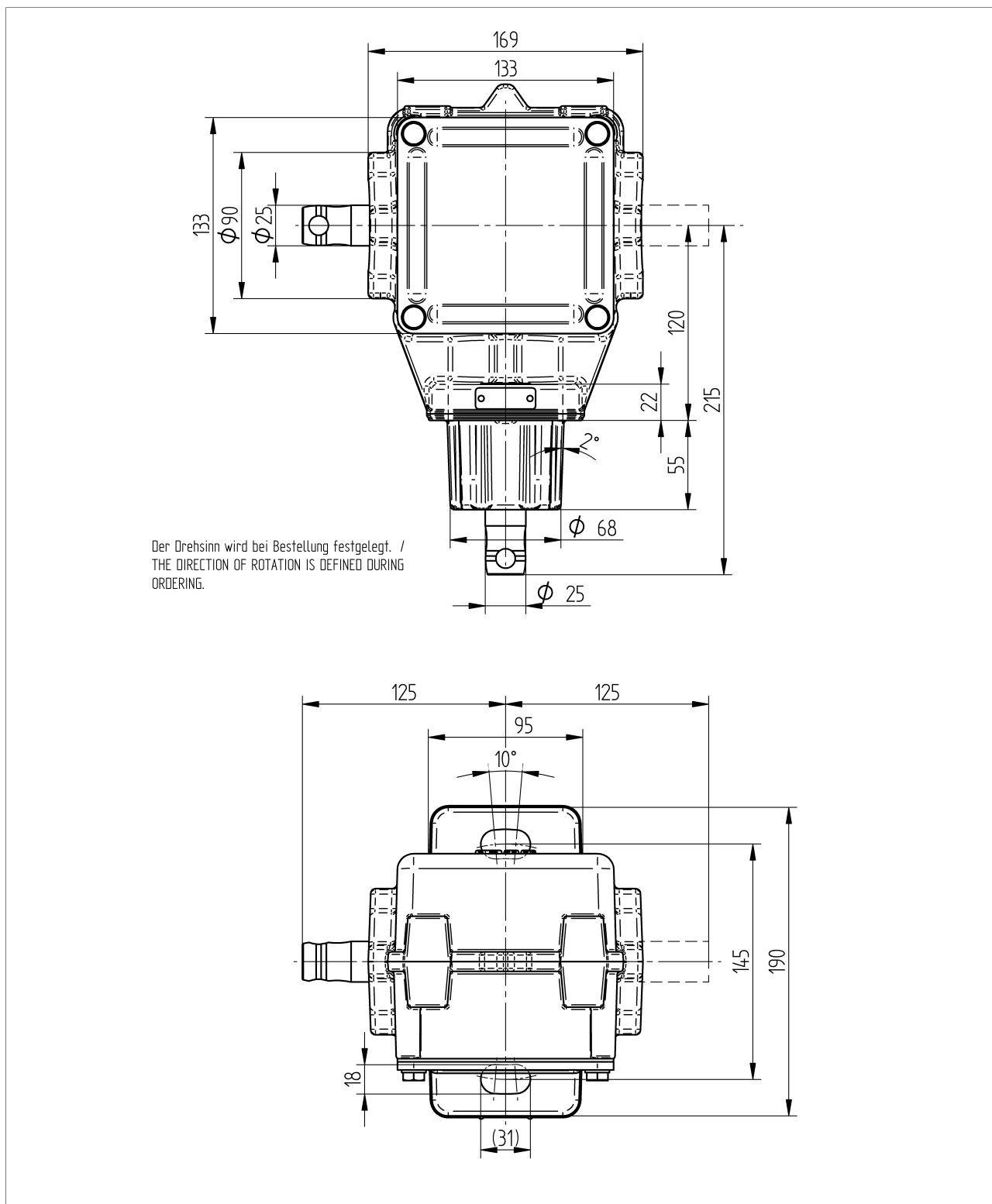


9.11 Socket wrench for kerosene drain plug (890182)



| SOCKET WRENCH                             | ITEM NO. 014820:<br>L = 1350 mm           | ITEM NO. 017660:<br>L = 1860 mm   |
|---|---|---|
| TO BE USED<br>FOR ON-LOAD<br>TAP-CHANGERS | TYPE M (EXEPT M Δ)<br>TYPE MS<br>TYPE VM® | TYPE M III 350 Δ / 600 Δ<br>TYPE T<br>TYPE R<br>TYPE RM<br>TYPE G<br>TYPE VR® |

9.12 Bevel gear CD 6400, dimensional drawing (892916)





## Glossary

### CO

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Change-Over contact

### DC

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Direct current

### Dielectric strength

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Material-specific property of isolators [kV/2.5 mm]; maximum electrical field strength without a breakdown (arc)

### IEC

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The International Electrotechnical Commission (IEC for short) is involved in the preparation and publication of international standards for electrical, electronic and related technologies.

### IP

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Ingress protection

### MR

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Maschinenfabrik Reinhausen GmbH

### NC

---

Normally Closed contact

### NO

---

Normally Open contact

### NPT

---

National Pipe Thread (US thread standard)



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- 10/21 - Maschinenfabrik Reinhausen GmbH 2021

THE POWER BEHIND POWER.

