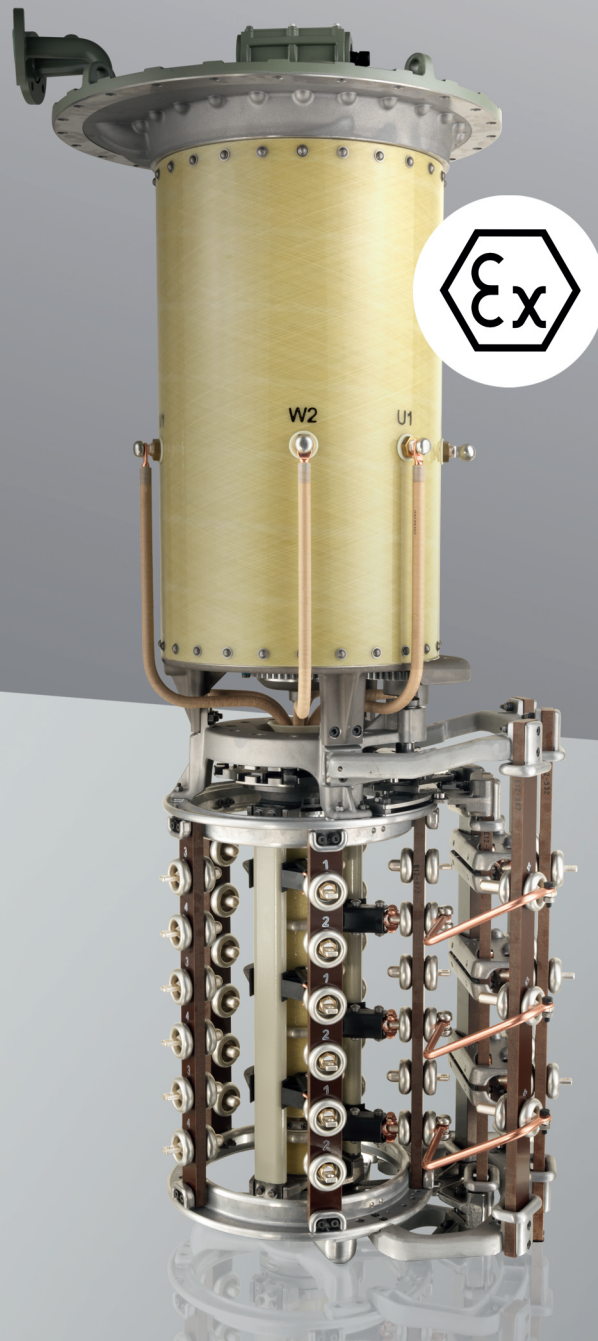




On-load tap-changer VACUTAP[®] VM-Ex

Operating Instructions

5293069/01 EN



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The product may have been altered since this document was published.

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 appropriate use:

- Use the product only with the transformer specified in the order.
- Only operate the product with the versions of the motor-drive unit, drive shaft and protective relay that have been approved for use in explosive areas.
- 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 technical file, the agreed-upon delivery conditions and the 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 file.
- The on-load tap-changer is not intended to be used with an oil filter unit.
- The measures described in this technical file must be taken in order to comply with explosion protection requirements.

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 1.5 times the rated through-current I_r at its rated step voltage U_{ir} .

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

The highest voltage for equipment U_m is limited to 245 kV.

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, malfunctions 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.

- Do not install the product in potentially explosive areas or in potentially explosive atmospheres.

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.

- For the on-load tap-changer oil compartment, use insulating fluids that meet the requirements in accordance with IEC 60296.
- If approved by the transformer manufacturer, you can use synthetic esters in accordance with IEC 61099.



- It is imperative that you consult with Maschinenfabrik Reinhausen GmbH because specific operating conditions apply to alternative insulating fluids.
- 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 Standards and regulations

2.4.1 Application range of the on-load tap-changer

The on-load tap-changer is certified for II 3G Ex ec oc IIC T3 Gc. Refer to the following overview for the resulting application range.

1	2	3	4	5	6	7	8
	II	3G	Ex	ec oc	IIC	T3	Gc

Table 3: Example of the application range

Number	Meaning
1	Sign for explosion protection
2	Equipment group
3	Equipment category
4	Ex: Symbol for explosion-protected equipment
5	Ignition protection type
6	Explosion group
7	Temperature class
8	EPL (equipment protection level)



Equipment groups (number 2)

I	Equipment in this category is intended for use in underground parts of mines as well as those parts of surface installations of such mines endangered by firedamp and/or combustible dust.
II	Equipment in this category is intended for use in other areas in which explosive atmospheres may be present.

Table 4: Equipment groups

Equipment category / zone classification (number 3)

Designation for gases	Designation for dusts	Definition
1G (0)	1D (20)	Equipment in this category is intended for use in areas in which explosive atmospheres caused by mixtures of air and gases, vapors or mists or by air/dust mixtures are present continuously, for long periods or frequently.
2G (1)	2D (21)	Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapors, mists or air/dust mixtures occur occasionally.
3G (2)	3D (22)	Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapors, mists, or air/dust mixtures are unlikely to occur or, if they do occur, are likely to do so only infrequently and for a short period only.

Table 5: Equipment category / zone classification

Ignition protection types (number 5)

d	Pressure-proof enclosure
e	Increased safety
i	Intrinsic safety (ia, ib)
m	Encapsulation
o	Liquid immersion Protection level "ob": Equipment protection level (EPL) "Gb" for zone 1 and zone 2 Protection level "oc": Equipment protection level (EPL) "Gc" for zone 2
p	Pressurized apparatus
q	Powder filling
n	Ignition protection type "n"

Table 6: Ignition protection types



Explosion group (number 6)

EN/IEC	Gases, vapors (examples)	Min. ignition energy (mJ)
IIA	Ammonia	-
IIA	Acetic acid, acetone, benzene, diesel, ethane, ether, fuel oil, hexane, methane, petrol, petroleum, propane	0.18
IIB	Ethylene, isoprene, town gas	0.06
IIC	Acetylene, carbon disulfide, hydrogen	0.02

Table 7: Explosion groups

Temperature classes (number 7)

Temperature class	Maximum equipment surface temperature	Ignition temperature of the flammable substances
T1	450°C	> 450°C
T2	300°C	> 300°C < 450°C
T3	200°C	> 200°C < 300°C
T4	135°C	> 135°C < 200°C
T5	100°C	> 100°C < 135°C
T6	85°C	> 85°C < 100°C

Table 8: Temperature classes

Equipment protection level (EPL) (number 8)

The EPL indicates the level of protection defined for a device based on the level of probability of ignition and taking into account the differences between potentially explosive gas atmospheres, potentially explosive dust atmospheres, and potentially explosive atmospheres in mine workings affected by firedamp.

2.4.2 Standards and regulations

The following standards and regulations apply to explosion-proof on-load tap-changers:

- EN/IEC 60079-0: Equipment – General requirements
- EN/IEC 60079-6: Equipment protection by liquid immersion "o"
- EN/IEC 60079-7: Equipment protection by increased safety "e"



2.5 Measures for ensuring compliance with explosion protection requirements

2.5.1 Measures taken by the manufacturer

Maschinenfabrik Reinhausen has taken the following measures for ensuring compliance with explosion protection requirements. You do not need to take any special measures in this regard.

2.5.1.1 Quality of the insulating oil in the on-load tap-changer

The quality of the insulating oil required by IEC 60296 and the quality of the synthetic esters required by IEC 61099 in the oil compartment of the on-load tap-changer is ensured by using vacuum cells with transition resistors.

2.5.1.2 Monitoring the oil temperature in the diverter switch oil compartment

A temperature sensor is provided in the on-load tap-changer head cover for monitoring the oil temperature in the diverter switch oil compartment. The corresponding temperature monitoring relay is in the TAPMOTION® ED-Ex.

Temperature monitoring prevents further switching of the on-load tap-changer when the maximum permitted temperature is reached. This maximum permitted temperature is factory-configured for each specific order for all on-load tap-changer types (maximum 130 °C) and secured against accidental incorrect adjustment.

2.5.2 Measures to be taken by the transformer manufacturer/operator

The following measures for ensuring compliance with explosion protection requirements must be taken by the transformer manufacturer/operator.

2.5.2.1 Prescribed protective and drive components

Operate the on-load tap-changer only in conjunction with the following components:

- Ex protective relay
- Ex motor-drive unit
- Ex drive shaft

2.5.2.2 Setting up the on-load tap-changer oil system

Operate the on-load tap-changer only with a suitable oil system. This diverter switch oil system consists of the diverter switch oil compartment, protective relay, and oil conservator of the on-load tap-changer. It ensures that enough insulating oil is present in the diverter switch oil compartment at all times.

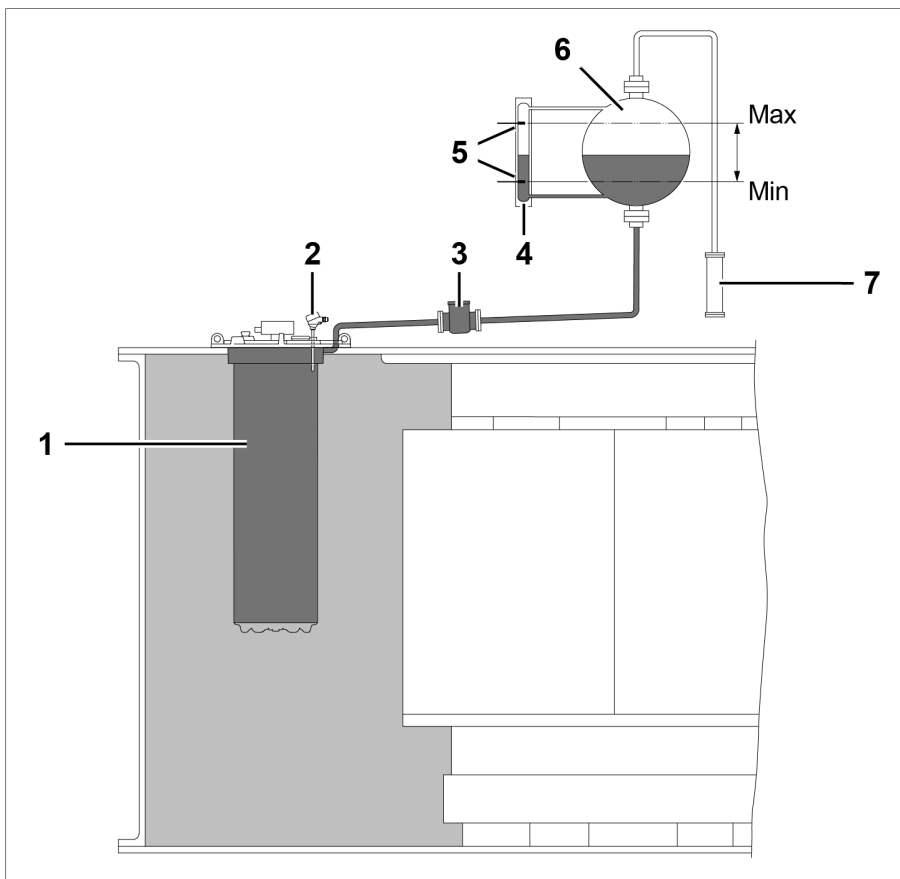


Figure 1: On-load tap-changer oil system

1 Diverter switch oil compartment	5 Signaling contacts
2 Temperature sensor	6 Oil conservator
3 Protective relay	7 Dehydrating breather
4 Level indicator	

2.5.2.3 Oil conservator to be used

The oil conservator of the on-load tap-changer ensures that sufficient insulating oil is present in the on-load tap-changer oil system at all times during operation.

Therefore, operate the on-load tap-changer only with a oil conservator that fulfills the following requirements:



2.5.2.3.1 Dehydrating breather

The oil conservator must be equipped with a dehydrating breather in accordance with VDE 0532-216-5 with downward-leading outlet and a protection degree of at least IP66 in accordance with IEC 60529.

2.5.2.3.2 Level indicator

The oil conservator must have a level indicator from which the minimum oil quantity required and the maximum quantity permitted, as well as the current oil level, can be read.

2.5.2.3.3 Level monitoring

The oil level in the oil conservator must be monitored at all times during operation. Therefore, loop the signaling contact for falling below the minimum oil level in the on-load tap-changer's oil conservator to the tripping circuit of the circuit breaker so that the circuit breaker will immediately de-energize the transformer when the oil level in the oil conservator falls below this minimum.

2.5.2.3.4 Insulating oil to be used

When filling the diverter switch oil compartment and its oil conservator, use only new mineral insulating oil for transformers in accordance with IEC 60296 (Specification for unused mineral insulating oils for transformers and switchgear) or synthetic ester in accordance with IEC 61099 (Specifications for unused synthetic organic esters for electrical purposes).

2.5.2.3.5 Checking the quality of the insulating oil in the Ex transformer

During the tap changes, polarity sparks (low energy) may occur at the tap selector of the on-load tap-changer in the transformer tank. In this regard, observe Section 5.1.6 and 5.1.7 in the on-load tap-changer standard IEC 60214.

Therefore, check the quality and dielectric strength of the insulating oil in the transformer tank on a regular basis and comply with the service intervals for the oil change.

2.5.2.4 Corrosion protection measures

Because further installation steps are required before operation of the on-load tap-changer, sufficient corrosion protection cannot be provided at certain interfaces to the transformer when the device leaves the factory.

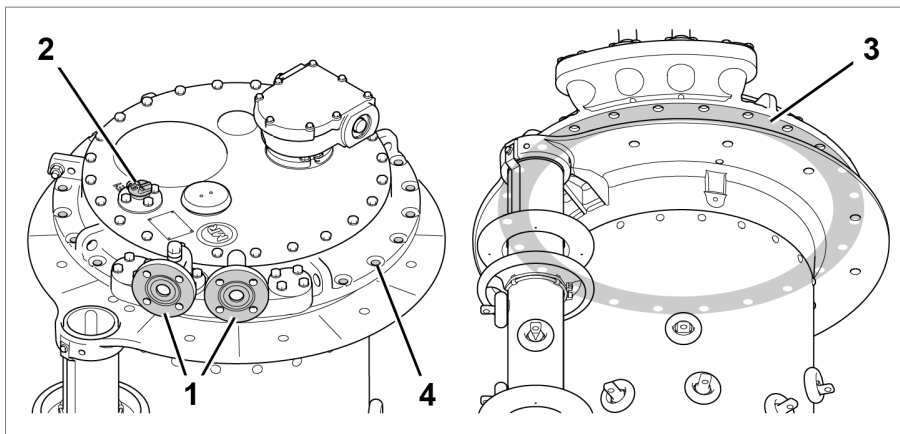


Figure 2: On-load tap-changer head

1 Sealing surface on piping connection flange	3 Contact surface on on-load tap-changer head
2 Air-vent valve	4 Through-holes

The sealing surfaces on the piping connection flange are zinc-plated ex factory. The through-holes are zinc-plated and partially painted.

The contact surface of the on-load tap-changer head is primed ex factory. The through-holes are primed and partially painted.

The transformer manufacturer is responsible for the design of the mating surfaces on the transformer and piping and that of the screw connections needed for these attachments.

1. Provide suitable sealing to prevent electrolytes from entering sealing surfaces and holes.
2. Design screws, washers, nuts etc. in A4 in accordance with ISO 3506-1/ISO 3506-2 standard.
3. If the painted surfaces are damaged, note repair instructions. These can be requested from Maschinenfabrik Reinhausen GmbH's Technical Service department.

2.6 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.



2.7 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.

Protective clothing	Close-fitting work clothing with a low tearing strength, with tight sleeves and with no protruding parts. It mainly serves to protect the wearer against being caught by moving machine parts.
Safety shoes	To protect against falling heavy objects and slipping on slippery surfaces.
Safety glasses	To protect the eyes from flying parts and splashing liquids.
Visor	To protect the face from flying parts and splashing liquids or other dangerous substances.
Hard hat	To protect against falling and flying parts and materials.
Hearing protection	To protect against hearing damage.
Protective gloves	To protect against mechanical, thermal, and electrical hazards.

Table 9: Personal protective equipment



3 Product description

3.1 Scope of delivery

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

- Oil compartment with on-load tap-changer head and built-in diverter switch insert
- Selector
- Ex motor-drive unit
- Ex drive shaft with coupling parts and bevel gear
- Ex protective relay
- Technical files

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



On-load tap-changers can also be provided as an on-load tap-changer set with a common motor-drive unit.

Note the following information:

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

You will find more information in the "Packaging, transport, and storage" chapter.

3.2 On-load tap-changer

3.2.1 Function description

On-load tap-changers are used to adjust the transmission ratio of transformers without interrupting the load flow. 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.

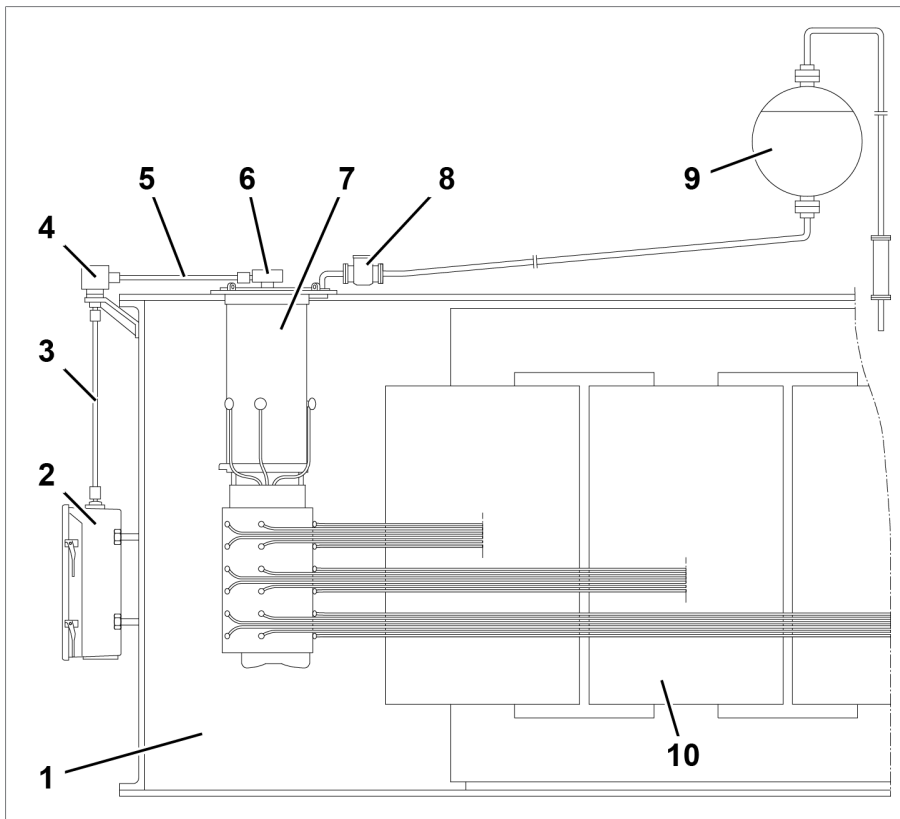


Figure 3: System overview of on-load tap-changer, transformer

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

3.2.2 Setup/models

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

The design and designation of the most important on-load tap-changer components are shown in the installation drawings in the appendix.

For the number of maximum operating positions of the on-load tap-changer, refer to the technical data.

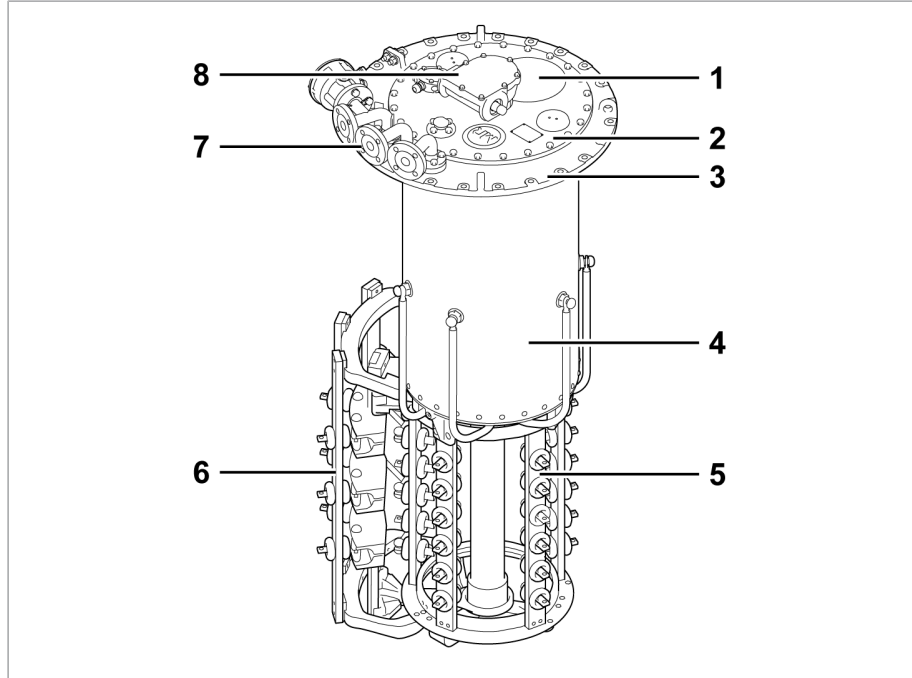


Figure 4: VACUTAP® VM

1 On-load tap-changer head

3 Selector

2 Oil compartment

4 Change-over selector

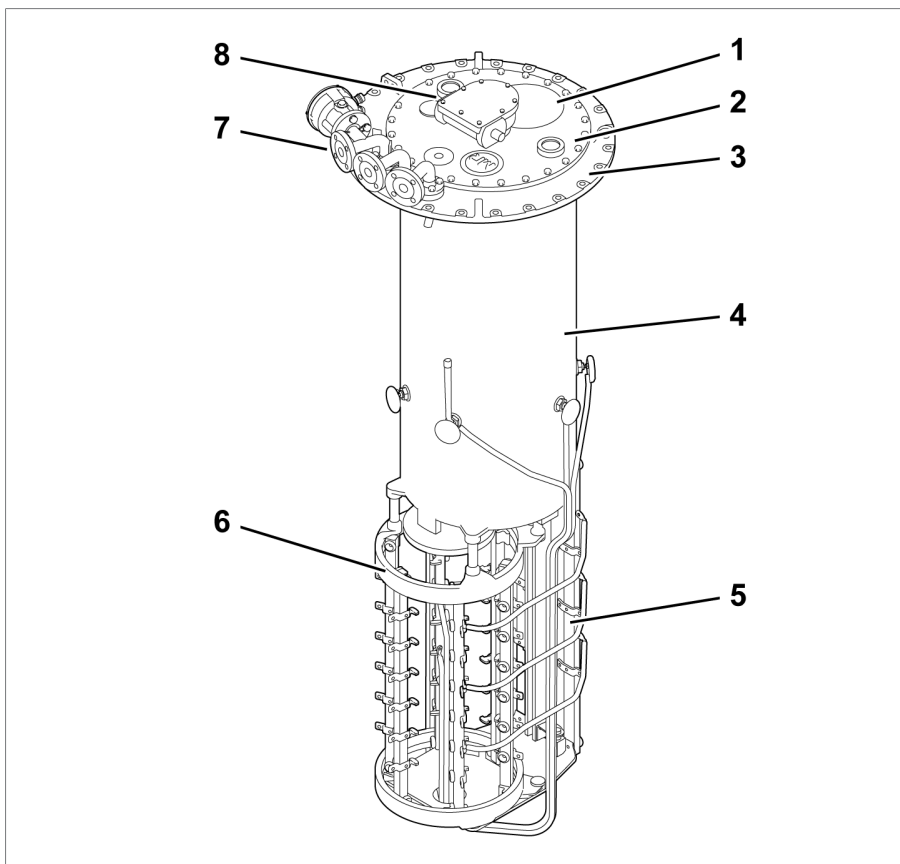


Figure 5: VACUTAP® VM 300

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

3.2.2.1 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 can be freely swiveled once the pressure ring is loosened.

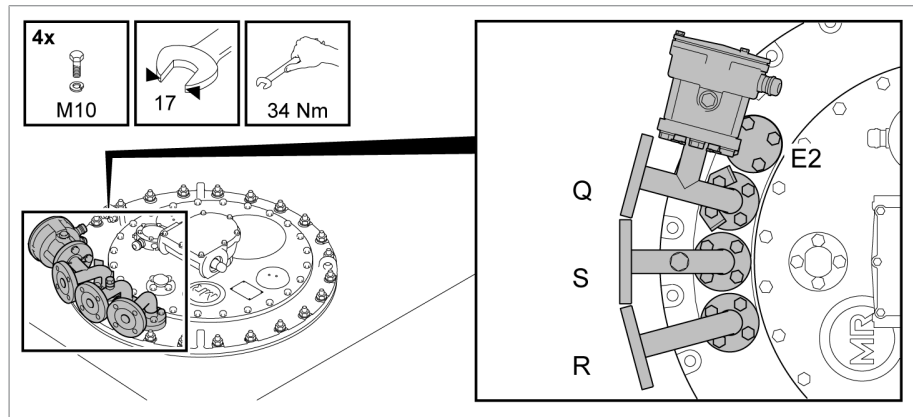


Figure 6: Pipe connections with pipe bends

Pipe connection Q

The pipe connection Q is closed with a blank cover.



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.

3.2.3 Nameplate and serial number

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

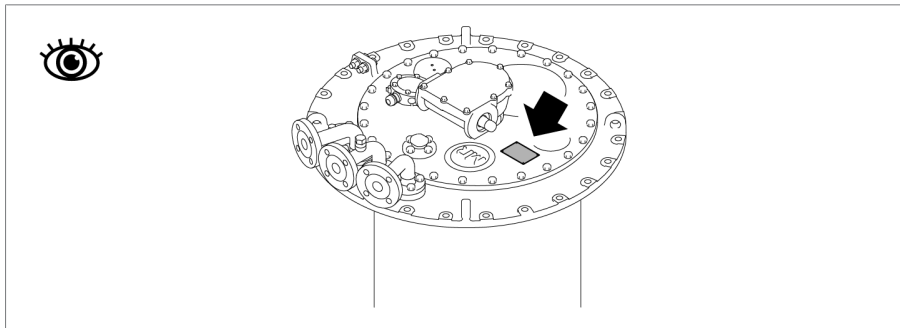


Figure 7: Nameplate

The serial number can also be found on the selector.

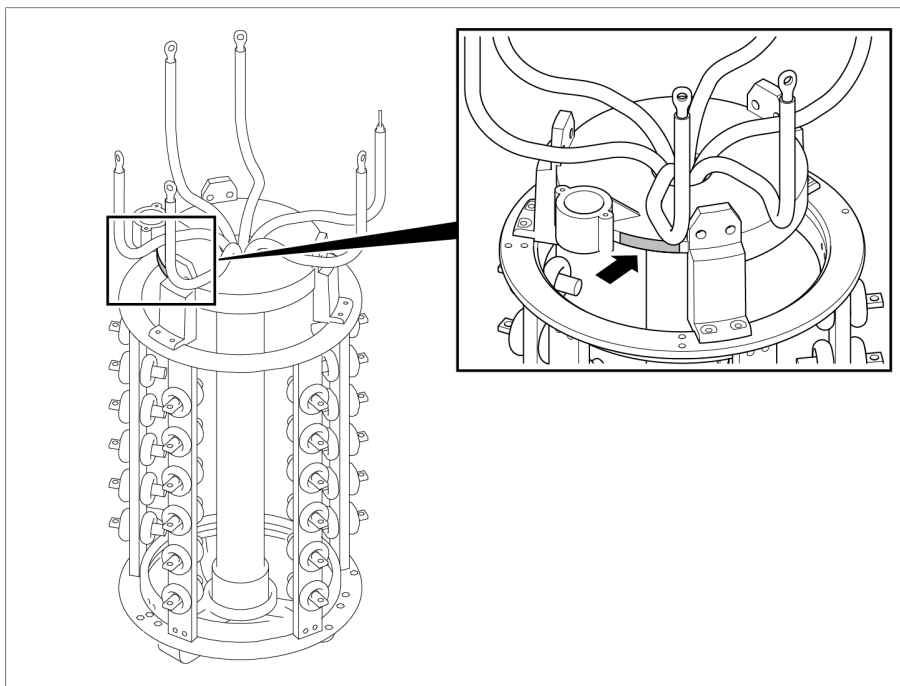


Figure 8: Serial number

3.2.4 Protective devices

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

3.2.4.1 Protective relay

3.2.4.1.1 Function description

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

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



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



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

3.2.4.1.2 Setup/versions

Front view

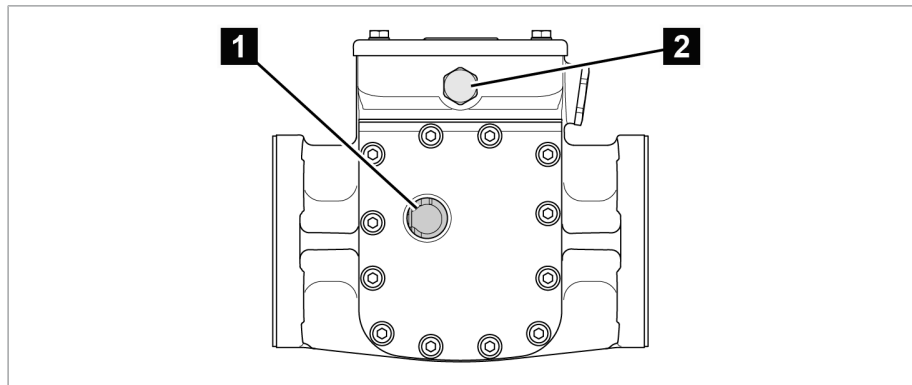


Figure 9: RS 2001-Ex

1 Inspection window

2 Pressure equalization element



Rear view

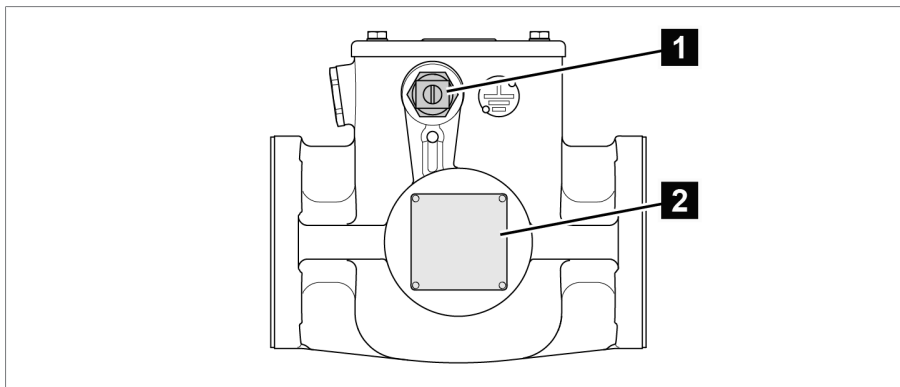


Figure 10: RS 2001-Ex

1 Ground connection

2 Nameplate

View from above

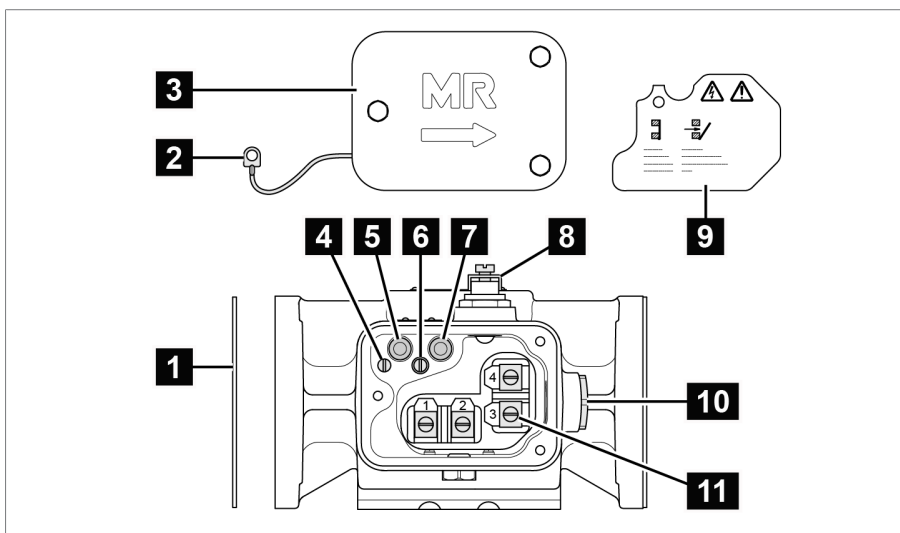


Figure 11: RS 2001-Ex

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 Protective conductor connection

9 Protective cover

10 Dummy plug

11 Connection terminal

3.2.4.1.3 Name plate

The name plate for the explosion-protected protective relay is on the rear of the product.

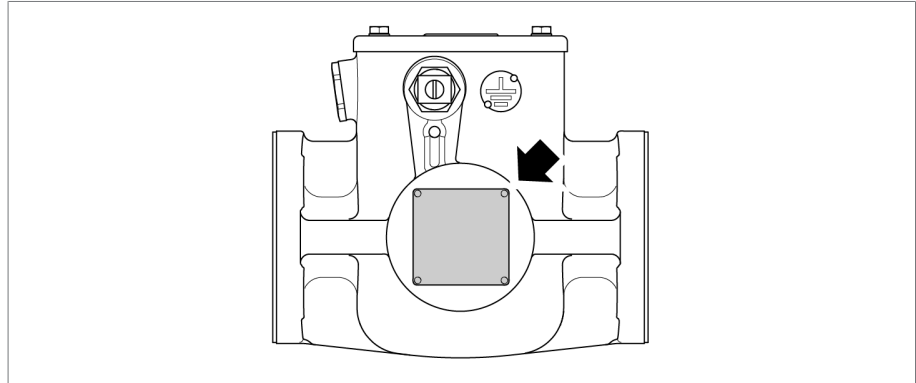


Figure 12: Position of name plate

3.2.4.2 Rupture disk

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

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

3.2.4.3 Temperature monitoring

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

3.3 Drive shaft

3.3.1 Function description

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

The bevel gear changes the direction from vertical to horizontal.

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

The explosion-proof drive shaft consists of a square tube with insulator and is coupled by two coupling brackets and one coupling bolt at both ends to the drive or driven shaft end of the device to be connected.

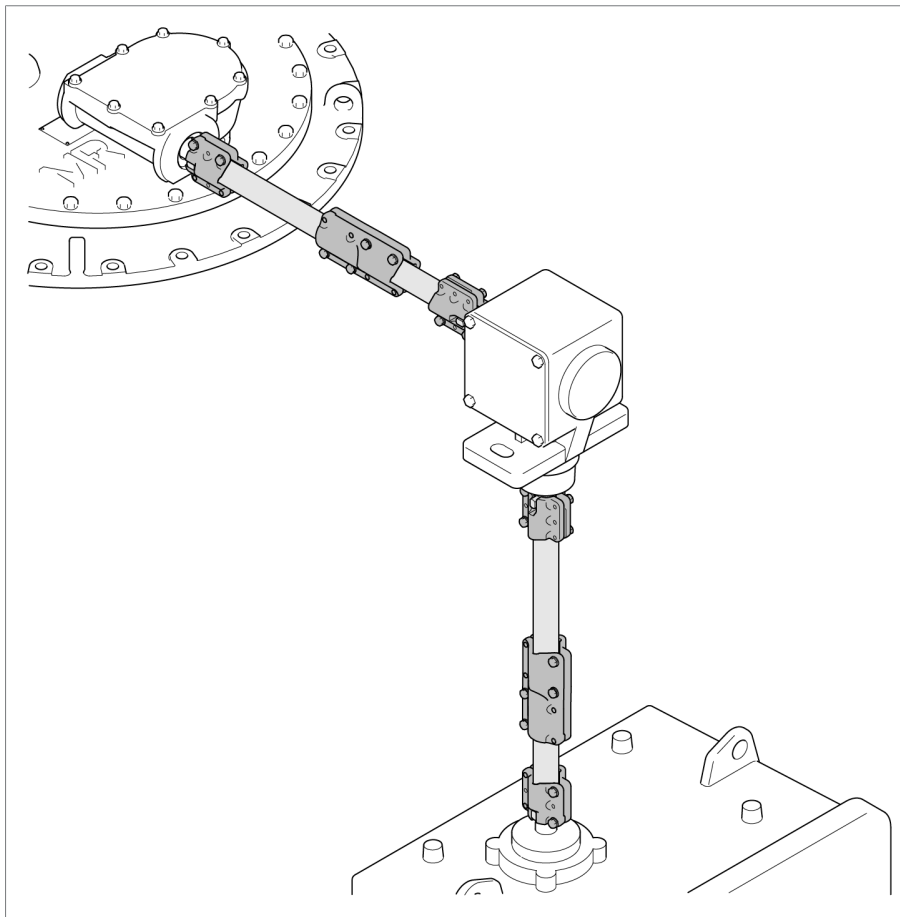


Figure 13: Explosion-proof drive shaft with insulator

3.3.2 Design/Model

The design of the explosion-proof drive shaft is described in this section.

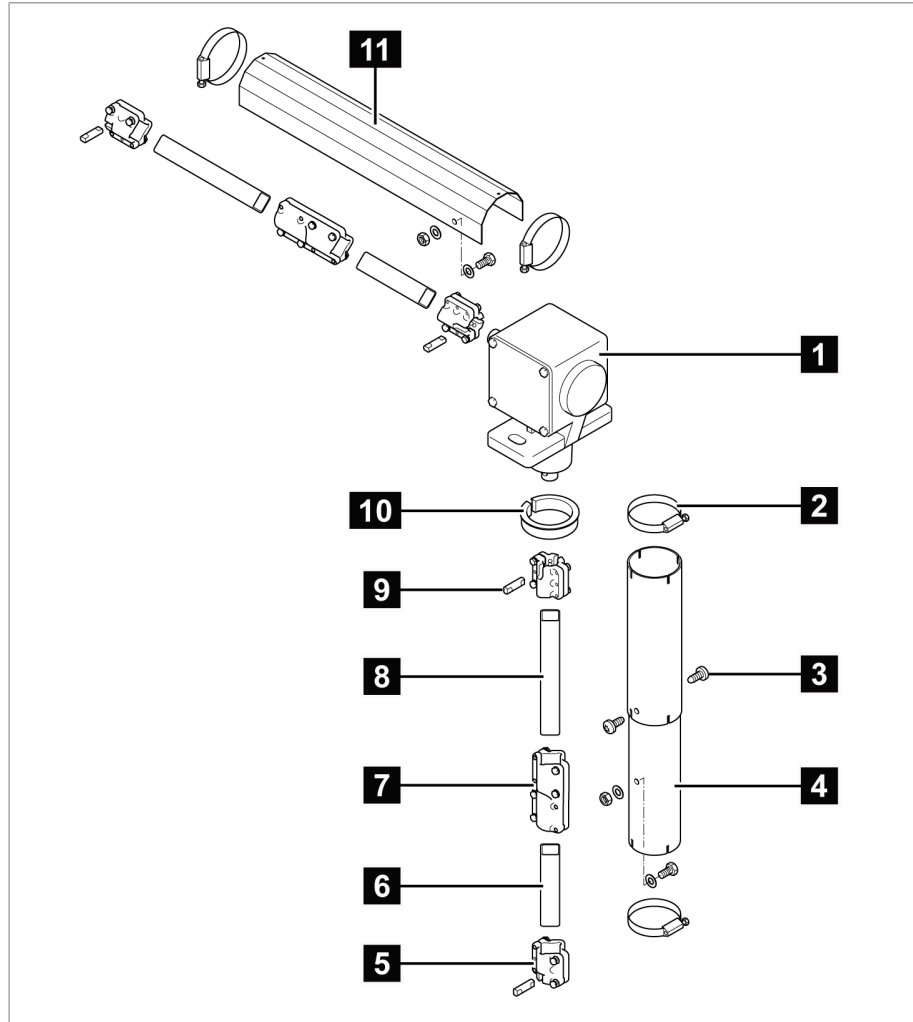
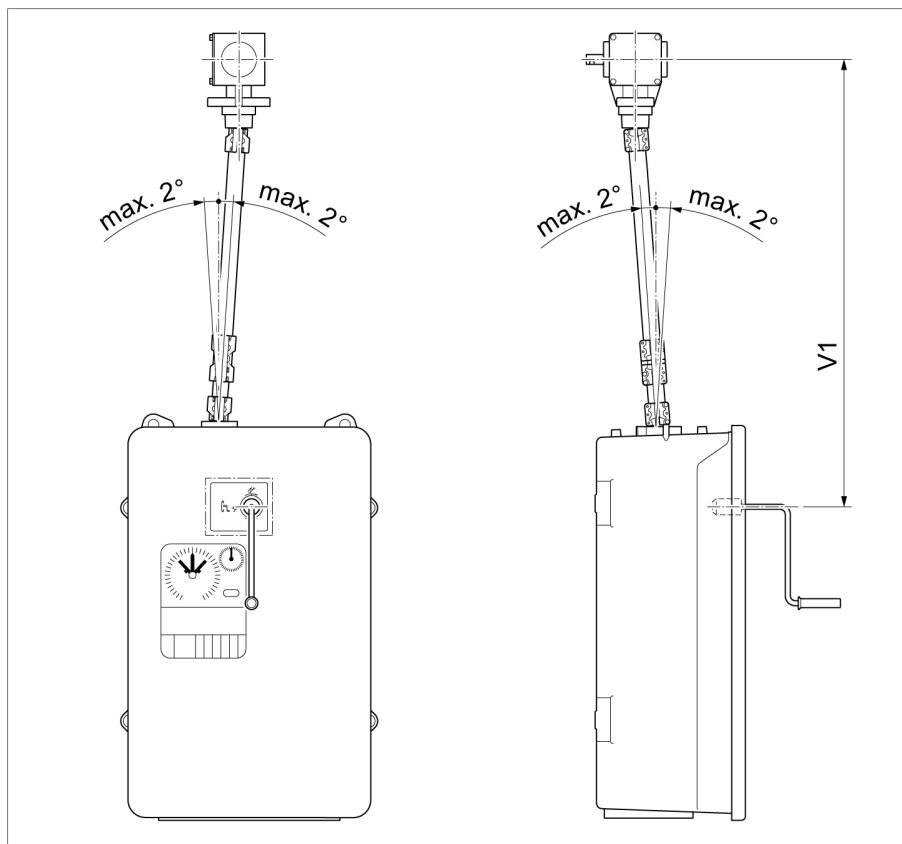


Figure 14: Components of the explosion-proof drive shaft

1 Bevel gear	2 Hose clip
3 Screws	4 Telescopic protective tube
5 Coupling bracket	6 Insulator
7 Double coupling bracket	8 Square tube
9 Pin	10 Adapter ring
11 Protective cover	



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

3.3.3 Identification plate

The identification plate is on the telescopic protective tube.

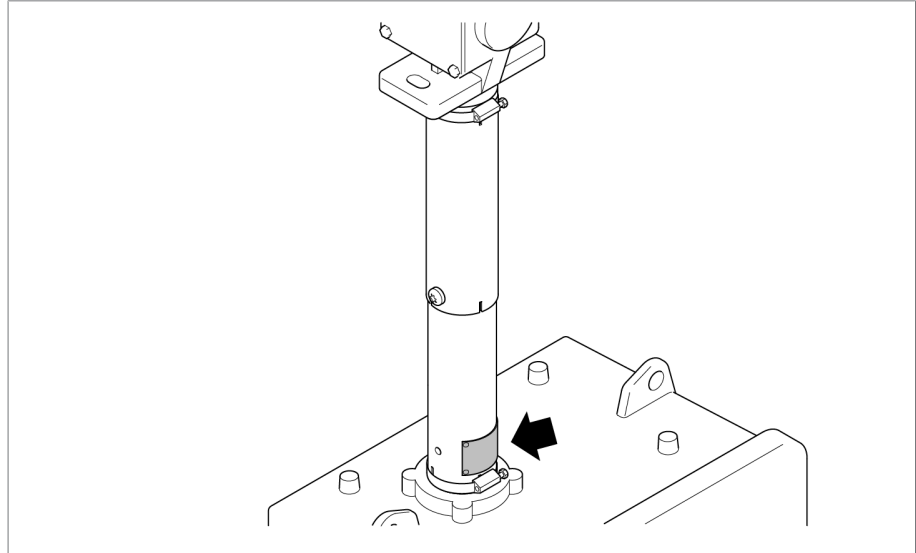


Figure 15: Position of the identification plate

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

Before energizing the transformer, check that the motor-drive unit and protective devices are functioning correctly and fill the on-load tap-changer oil compartment with fresh insulating fluid.

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.

- ▶ Use insulating fluids that meet the requirements in accordance with IEC 60296.
- ▶ If approved by the transformer manufacturer, you can use synthetic esters in accordance with IEC 61099 or natural esters in accordance with IEC 62770 approved by Maschinenfabrik Reinhausen GmbH.

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

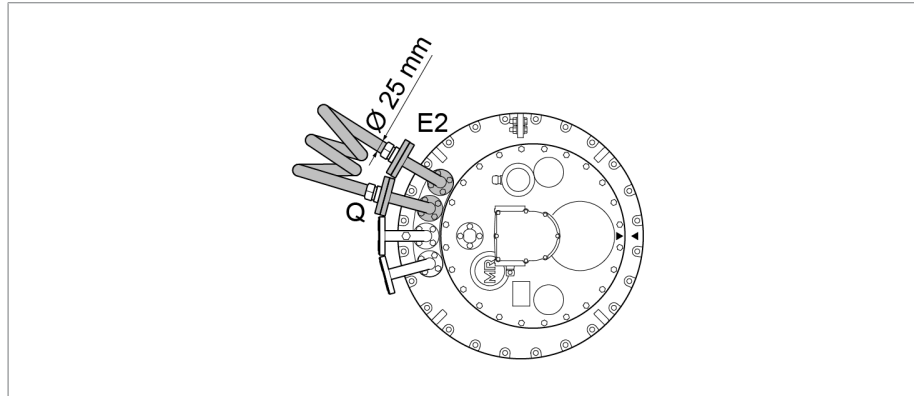


Figure 16: Connecting lead between E2 and Q

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

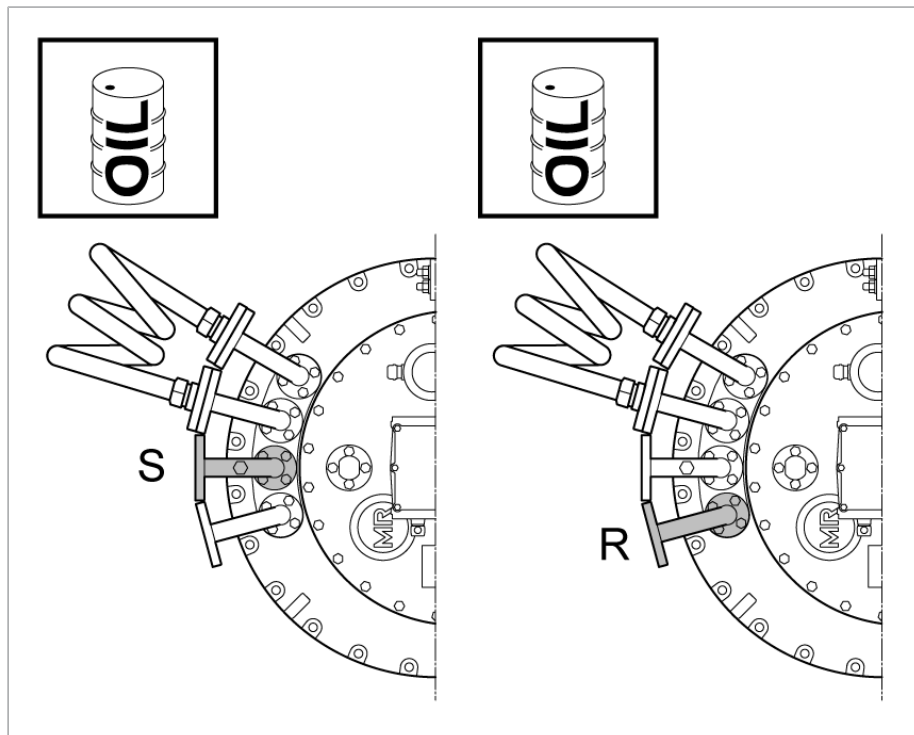


Figure 17: Pipe connections S and R

3. Take an insulating fluid sample from the oil compartment.
4. Record the temperature of the sample immediately after the sample is taken.

5. Determine the dielectric strength and water content at a sample temperature of $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The dielectric strength and water content must comply with the limit values [► Section 8.3, Page 63] 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.

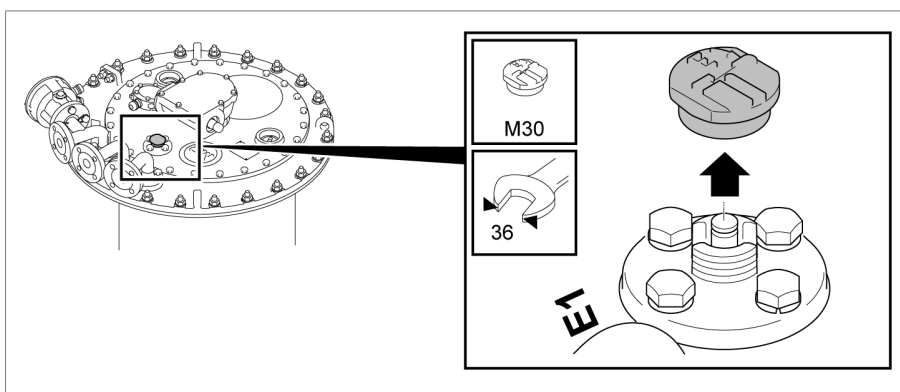


Figure 18: Screw cap

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

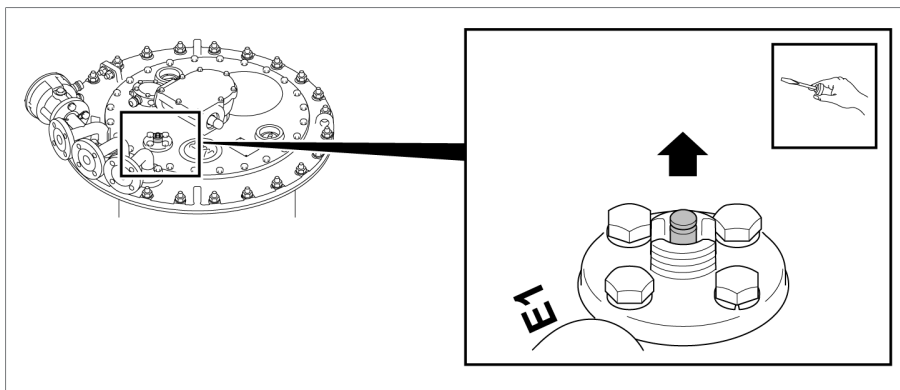


Figure 19: Valve tappet

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.

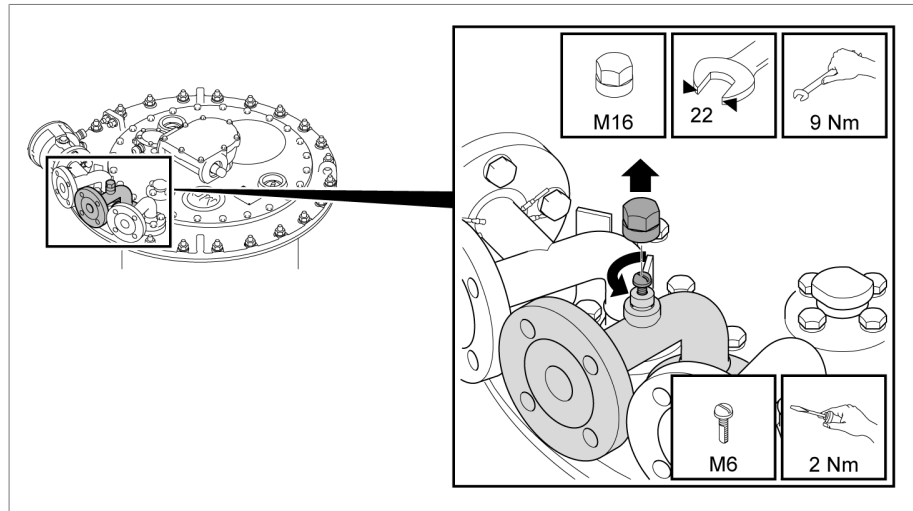


Figure 20: Screw cap

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

- ✓ Check that the protective relay is functioning correctly before commissioning the transformer:
 1. Ground the transformer on the high-voltage and low-voltage sides. Ensure that the working ground connection on the transformer is not removed during testing.
 2. Ensure that transformer remains de-energized during testing.
 3. Deactivate the automatic fire extinguishing device.
 4. Open terminal box of protective relay.
 5. Press OFF test button.
 6. Leave the transformer's danger zone.
 7. Ensure that the transformer's circuit breaker cannot be closed.
 - ⇒ Passive protection test



8. Press IN SERVICE test button.
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. Press OFF test button.
12. Ensure that the transformer's circuit breaker is open.
 - ⇒ Active protection test.
13. Press IN SERVICE test button to reset the protective relay.

4.1.5 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 Actuating motor-drive unit with hand crank

▲ WARNING



Danger of explosion!

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

- ▶ Only ever open the motor-drive unit when it is de-energized and wait at least 30 minutes after the voltage supply has failed or the motor-drive unit has been switched off before you open it.
- ▶ 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:

✓ Ensure that the protective gas supply has been switched off.

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 and transformer 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.
8. **⚠ DANGER!** Risk of explosion! Pre-flush the motor-drive unit and check the leakage loss rate.



6 Fault elimination

▲ WARNING



Danger of explosion!

Danger of death from explosive gases under the on-load tap-changer head cover!

- ▶ Ensure that there are no open flames, hot surfaces or sparks (for example caused by static charging) in the immediate surroundings and that none arise.
- ▶ De-energize all auxiliary circuits (for example tap-change supervisory device) before removing the on-load tap-changer head cover.
- ▶ Do not operate any electrical devices during the work (for example risk of sparks caused by impact wrench).
- ▶ Only use conductive and grounded hoses, pipes, and pump equipment that are approved for flammable liquids.

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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 Internet: www.reinhausen.com

Fault description	Action
Tripping of protective relay (for example RS-Ex)	See "Tripping of the protective relay and re-commissioning the transformer". Also contact MR.
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. Contact MR to check the on-load tap-changer.
Tripping of motor protective switch in motor-drive unit	See the "Fault elimination" chapter in the operating instructions of the TAPMOTION® ED-Ex motor-drive unit.
Tripping of signaling contact that indicates that the oil level has fallen below the minimum oil level in the on-load tap-changer oil conservator	Check pipe system (pipes etc.) and on-load tap-changer head for leaks. Check oil level and oil quality of diverter switch oil in accordance with operating instructions for 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.
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 10: 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

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.
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 is limited to occasional visual checks of on-load tap-changer head, protective relay, and motor-drive unit. For efficiency reasons these visual inspections can be combined with the usual checks on the transformer.

Check the following:

Interval	Action
Annually	Check the drive shaft's lubrication points for sufficient lubrication. You will find the lubrication points in the installation description.
Annually	Check upper gear unit and bevel gear for seal integrity and damage.
Annually	Check air-vent valve on on-load tap-changer head cover for seal integrity.
Annually	Check door seal, cable bushings, and ventilation of protective housing of motor-drive unit.
Annually	Check coating of on-load tap-changer head, attachments, and accessories.
Annually	Check sealing points of on-load tap-changer head, protective relay, and connected pipes.
Annually	Check correct functioning of the installed electrical heater in the protective housing of the motor-drive unit.
Annually	Check correct function of protective relay.
Annually	Check perfect condition of the silica gel breather for the on-load tap-changer oil conservator.



Interval	Action
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 60214-1).</p> <ol style="list-style-type: none"> 1. Take a sample of insulating fluid from the oil compartment. 2. Record the temperature of the sample (insulating fluid) immediately after the sample is taken. 3. Determine the dielectric strength and water content at an insulating fluid temperature of $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The dielectric strength and water content must comply with the limit values specified in the technical data. 4. If the limit values are not complied with, change the insulating fluid in accordance with the "Changing the insulating fluid" section.
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 60214-1).</p> <ol style="list-style-type: none"> 1. Take a sample of insulating fluid from the oil compartment. 2. Record the temperature of the sample (insulating fluid) immediately after the sample is taken. 3. Determine the dielectric strength and water content at an insulating fluid temperature of $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The dielectric strength and water content must comply with the limit values specified in the technical data. 4. If the limit values are not complied with, change the insulating fluid in accordance with the "Changing the insulating fluid" section.

Table 11: 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.

Interval	Action
after 150,000 switching operations (motor-drive unit counter reading)	Maintenance of the on-load tap-changer
after 1.2 million switching operations (motor-drive unit counter reading)	Selector maintenance
after 1.2 million switching operations (motor-drive unit counter reading)	Replacement of diverter switch insert

Table 12: Maintenance plan without MR monitoring system

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

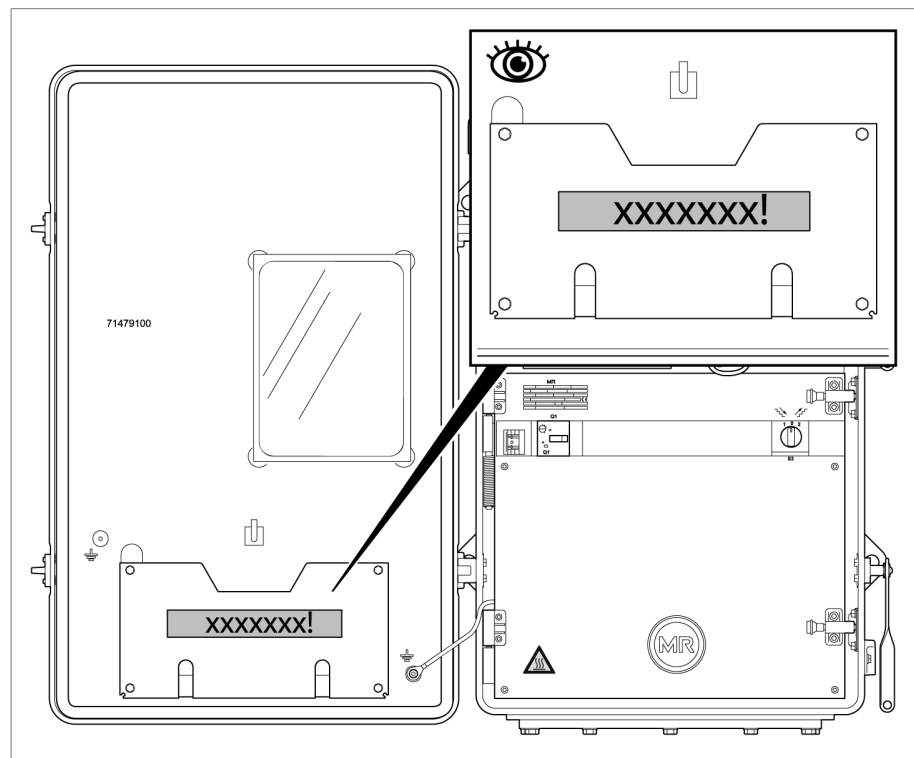


Figure 21: Label showing maintenance intervals



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 Changing the insulation fluid

NOTICE

Damage to the on-load tap-changer!

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

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

Change the insulating fluid in the on-load tap-changer oil compartment and oil conservator if the dielectric strength and water content are not in compliance with the limit values specified in the technical data.

7.3.1 Moving on-load tap-changer to adjustment position

1. Make a note of the current operating position of the on-load tap-changer.
2. Move the on-load tap-changer to the adjustment position. The adjustment position is indicated in the on-load tap-changer connection diagram included in delivery.

7.3.2 Removing horizontal drive shaft

NOTICE

Damage to the on-load tap-changer and transformer!

Damage to on-load tap-changer and transformer if motor-drive unit is operated when not coupled!

- ▶ Never operate the motor-drive unit if the horizontal drive shaft has been removed.
- ▶ As a precaution, block the motor-drive unit against electrical operation by actuating the motor protective switch (see operating instructions for "Tap-motion® ED").

1. Loosen hose clips on protective cover of horizontal drive shaft, remove protective cover.

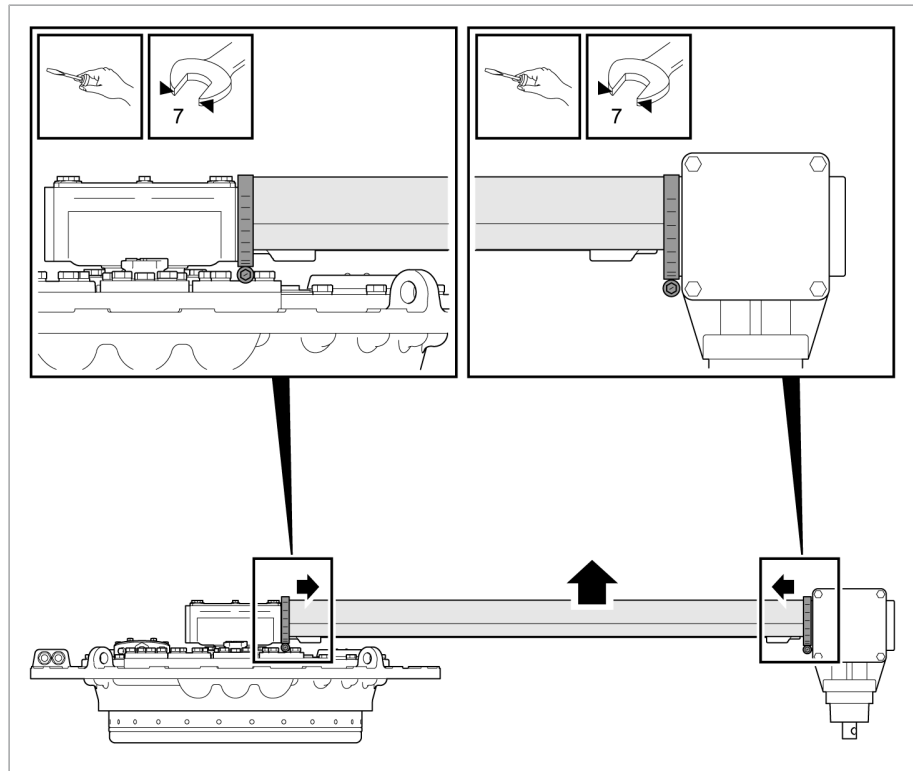


Figure 22: Removing protective cover

2. Depending on version, loosen 4 or 6 screws on coupling brackets to upper gear unit and bevel gear.

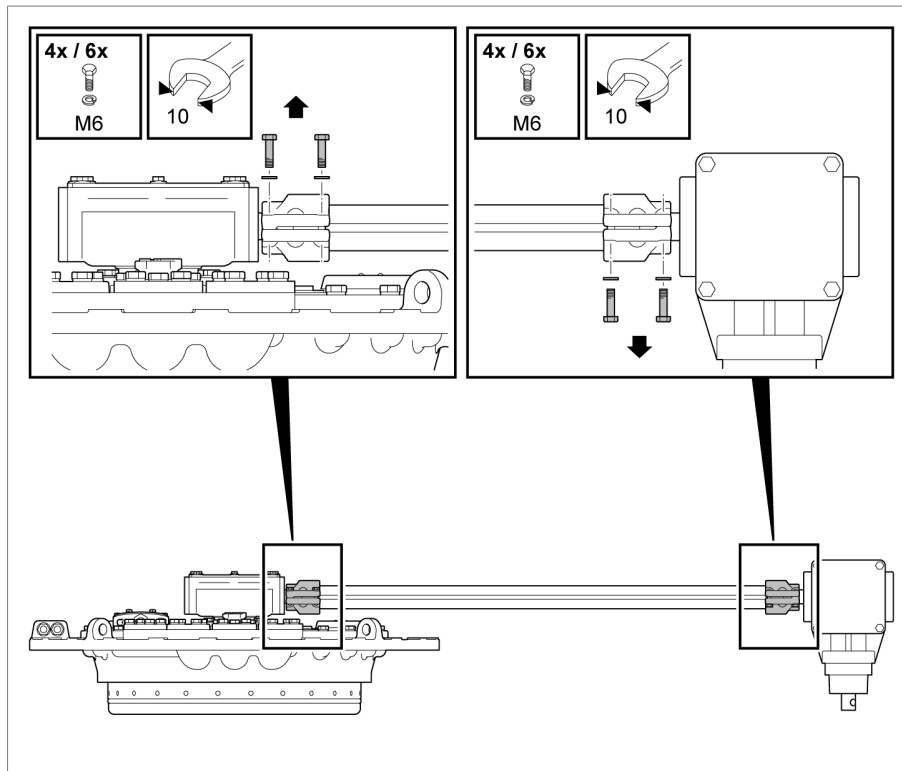


Figure 23: Loosening coupling brackets

3. Remove horizontal drive shaft. Be sure not to lose the coupling bolts.

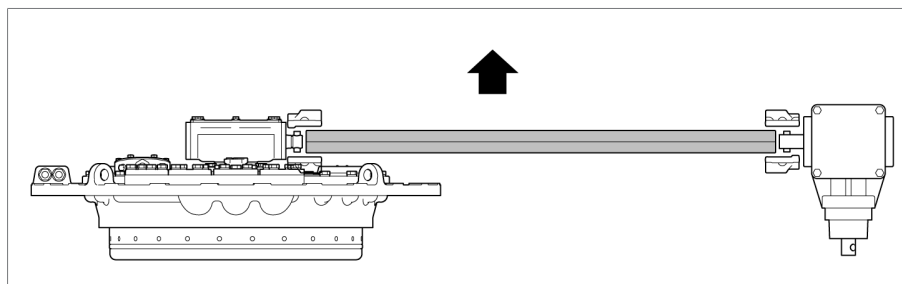


Figure 24: Removing drive shaft

7.3.3 Emptying the oil compartment and oil conservator

1. Ensure that the stop-cock between oil conservator and on-load tap-changer is open.
2. Remove the screw cap on air-vent valve E1 on the on-load tap-changer head cover.
3. Use a screwdriver to lift the valve tappet on air-vent valve E1.
 - ⇒ The gas under the on-load tap-changer head cover escapes. When doing so, ensure sufficient ventilation.

4. Once the gas has been discharged and insulating fluid is flowing out of the air-vent valve, close the air-vent valve.
5. Close the stop-cock between the oil conservator and on-load tap-changer.
6. Open air-vent valve E1 again and extract approximately 5–10 liters of insulating fluid via the pipe connection S until the area under the on-load tap-changer head cover is free of insulating fluid.
7. Remove the screws and washers from the on-load tap-changer head cover.

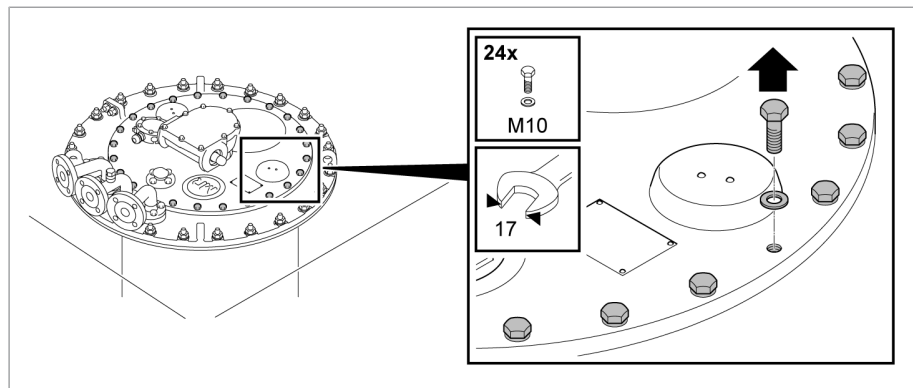


Figure 25: On-load tap-changer head cover

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

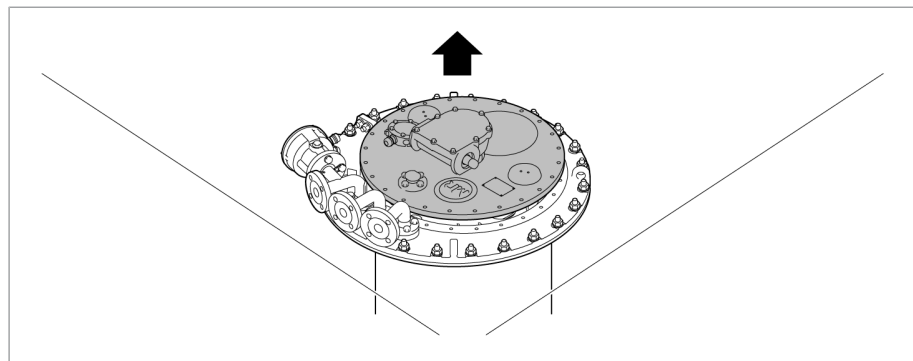


Figure 26: On-load tap-changer head cover

9. Extract insulating fluid via pipe connection S.
10. Open the stop-cock between oil conservator and on-load tap-changer.
 - ⇒ The insulating fluid flows out of the oil conservator into the oil compartment.
11. Extract insulating fluid via pipe connection S.

7.3.4 Filling the oil compartment and oil conservator with fresh insulating fluid

NOTICE

Damage to the on-load tap-changer!

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

- ▶ Use insulating fluids that meet the requirements in accordance with IEC 60296.
- ▶ If approved by the transformer manufacturer, you can use synthetic esters in accordance with IEC 61099 approved by Maschinenfabrik Reinhausen GmbH.
- ▶ Ensure that the new insulating fluid has the same chemical, mechanical, thermal and electrical properties. Otherwise contact Maschinenfabrik Reinhausen GmbH's Technical Service department.

1. Fill the oil compartment of the on-load tap-changer with fresh insulating fluid via the pipe connection S up to the level of the upper edge of the coupling shaft.
2. Insert the new O-ring untwisted in the on-load tap-changer head cover.
3. Position the on-load tap-changer head cover on the on-load tap-changer head in such a way that the red triangular markings on the on-load tap-changer head and the on-load tap-changer head cover are aligned.

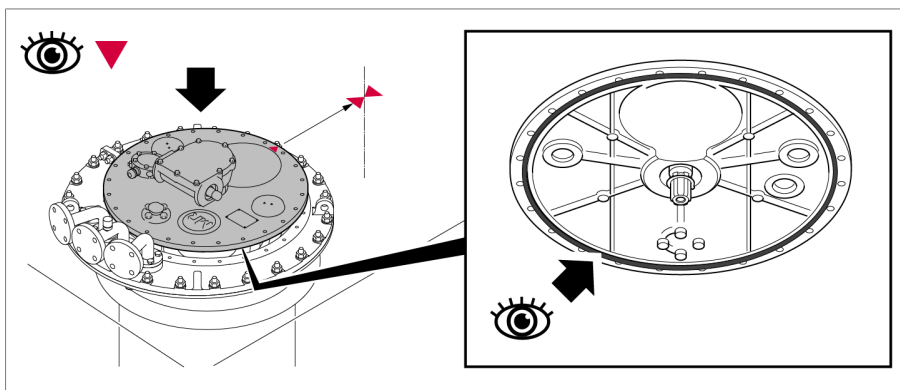


Figure 27: Triangular markings and o-ring

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

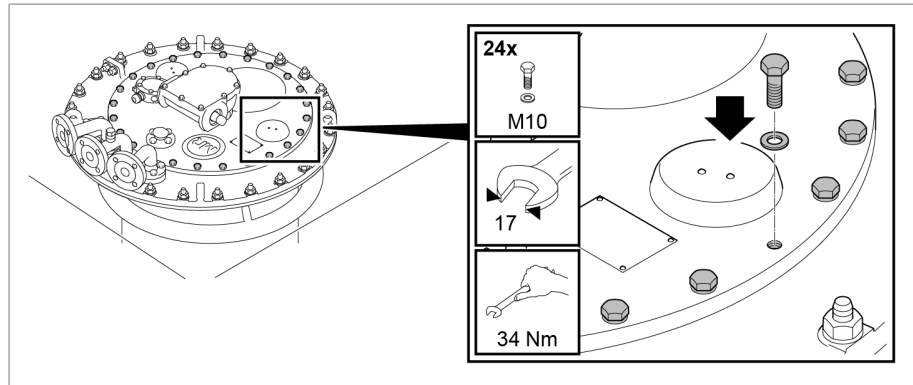


Figure 28: On-load tap-changer head cover

5. Fill the oil conservator with fresh insulating fluid.
6. Vent the on-load tap-changer head via air-vent valve E1 on the on-load tap-changer head cover. To do this, remove screw cap and lift valve tappet with a screwdriver.
7. Seal air-vent valve E1 with screw cap (tightening torque 10 Nm).
8. Remove screw cap from pipe connection S.

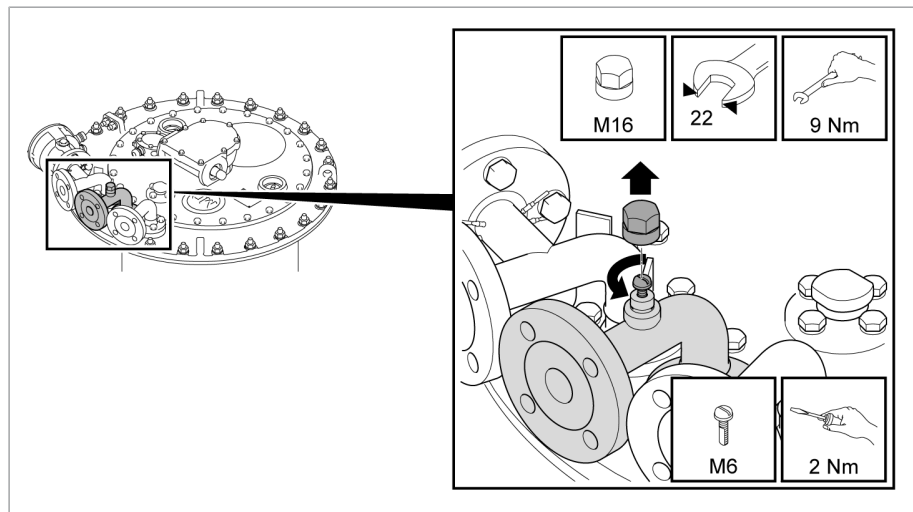


Figure 29: Pipe connection S

9. Open vent screw and bleed piping.
10. Close vent screw.
11. Seal vent screw with screw cap.
12. Check the level in the oil conservator and top up with insulating fluid if necessary.
13. Re-vent the on-load tap-changer head via air-vent valve E1 and the pipe connection S via the vent screw.

14. Flush the oil suction pipe and take an insulating fluid sample from the oil compartment via pipe connection S.
15. Record the temperature of the sample immediately after the sample is taken.
16. Determine the dielectric strength and water content at a sample temperature of $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The dielectric strength and water content must comply with the limit values specified in the technical data (after maintenance).

7.3.5 Installing horizontal drive shaft

1. Secure horizontal drive shaft between upper gear unit and bevel gear with coupling brackets and 4 or 6 screws. Refer to the drive shaft operating instructions for details.

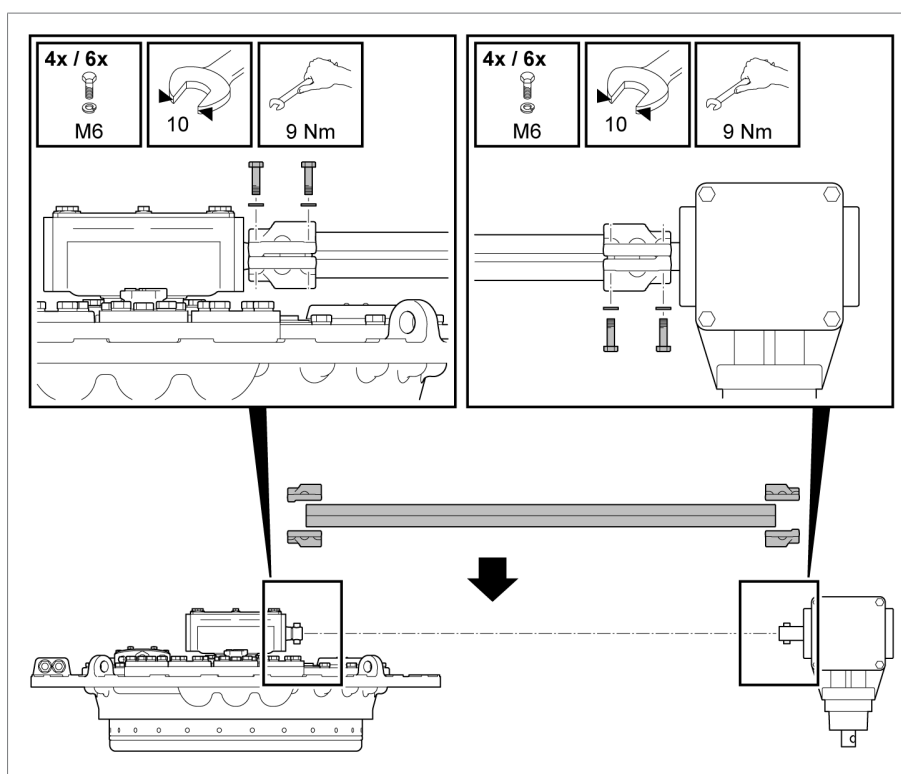


Figure 30: Securing drive shaft

2. Use hose clips to secure protective cover to horizontal drive shaft.

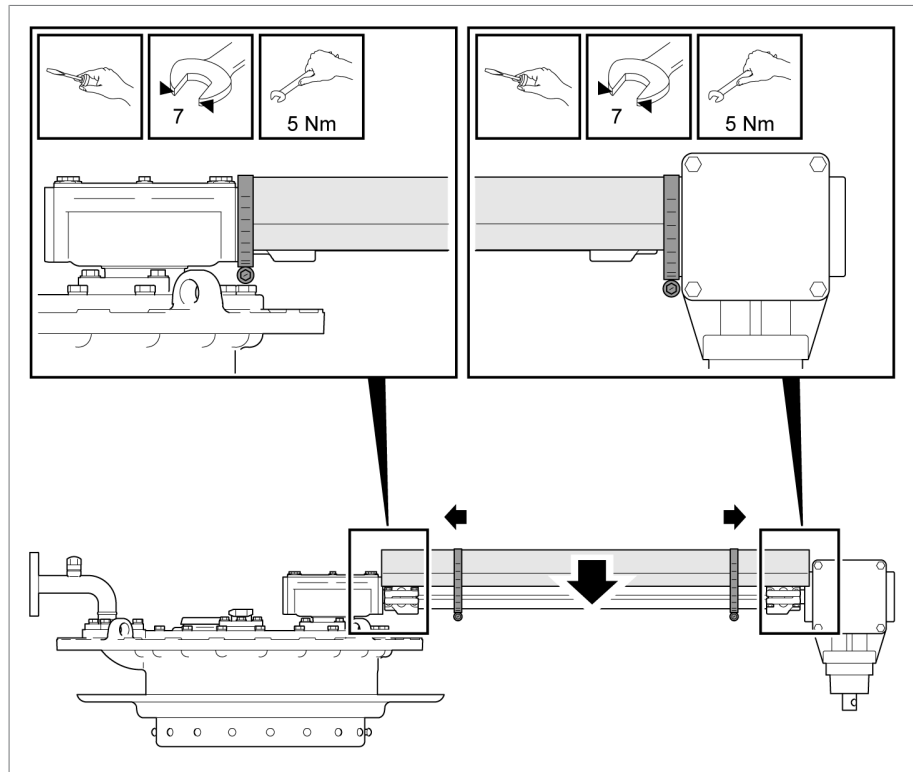


Figure 31: Securing protective cover

3. For special design types featuring cardan shafts, be sure to check the expansion bellows and the lubricant reservoir of the cardan shafts.

You will find a detailed description of how to fit the drive shaft in the **MR** operating instructions "Drive shaft".

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

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

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 13: 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	Insulating fluid in accordance with IEC 60296: -25°C...+105°C (when the transformer is in emergency operation based on IEC 60076-7, up to +110°C in accordance IEC 60214-1) Synthetic ester liquid in accordance with IEC 61099: -15°C...+105°C (when the transformer is in emergency operation, up to +115°C)
Transport temperature, storage temperature	-40°C...+50°C
Drying temperatures	See installation and commissioning instructions, "Assembly" chapter
Compressive strength	See technical data TD 61 – General Section
Alternative insulating fluids	Synthetic ester liquid (IEC 61099) on request
Installation height of the oil conservator	See technical data TD 61 – General Section
Installation height above sea level	See technical data TD 61 – General Section

Table 14: Permissible ambient conditions

8.2 Technical data for protective relay

The technical data for the protective relay RS 2001-Ex is listed in the following. In accordance with DIN EN 60255-1, operational accuracy = base accuracy

Housing	Outdoor model
Degree of protection	IP 66
Relay actuation	Flap valve with aperture
Vibration immunity	up to max. 3g
Weight	approx. 3.5 kg
Oil flow speed of available types when tripped (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 15: General technical data

Tripping circuit

The protective relay can be supplied with two independent dry-reed magnetic switches. These can be designed as normally open (NO) or normally closed (NC) contacts (see dimensional drawing supplied).



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 16: 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 17: 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 18: Dielectric strength

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 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)



Switching capacity (switching load on an off)	
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 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	2,000 V, 50 Hz, test duration 1 minute

Table 21: Dielectric strength

Ambient conditions

Ambient temperature T_a	-25 °C...+50 °C
Oil temperature	<130 °C
Air pressure	Corresponds to 0 m...4,000 m above mean sea level

Table 22: Ambient conditions

8.2.1 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



8.3 Limit values for dielectric strength and water content of insulating fluids

The following tables specify 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 the VACUTAP® on-load tap-changer. The values have been determined based on IEC 60422, IEC 61203 and IEEE C57.147.

Limit values for insulating fluids in accordance with IEC 60296	U _d	H ₂ O
When commissioning the transformer for the first time	> 60 kV/2.5 mm	< 12 ppm
During operation	> 30 kV/2.5 mm	< 30 ppm
After maintenance	> 50 kV/2.5 mm	< 15 ppm

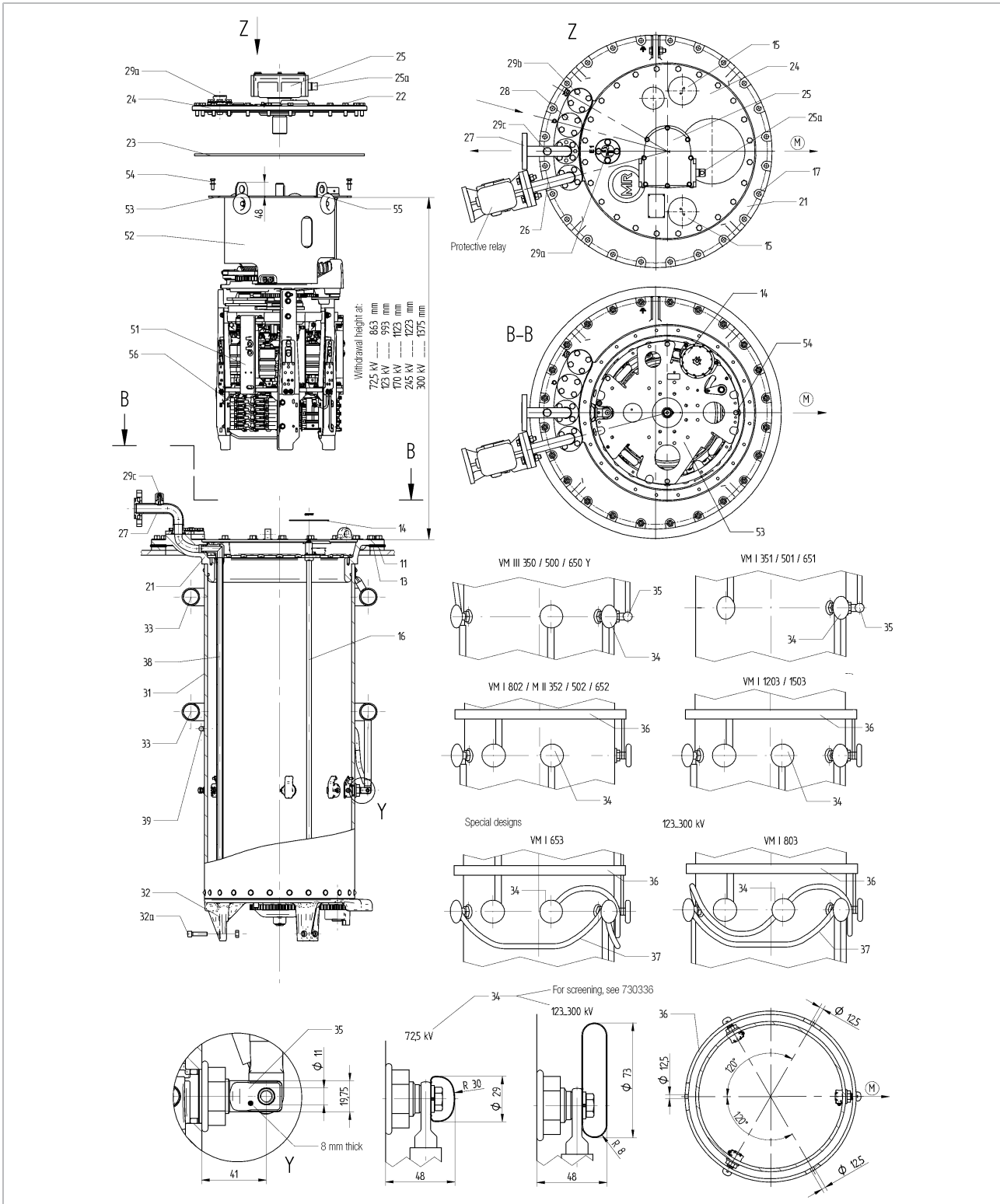
Table 23: Insulating fluids in accordance with IEC 60296

Limit values for synthetic esters in accordance with IEC 61099	U _d	H ₂ O
When commissioning the transformer for the first time	> 60 kV/2.5 mm	≤ 100 ppm
During operation	> 30 kV/2.5 mm	≤ 400 ppm
After maintenance	> 50 kV/2.5 mm	≤ 150 ppm

Table 24: Synthetic esters in accordance with IEC 61099

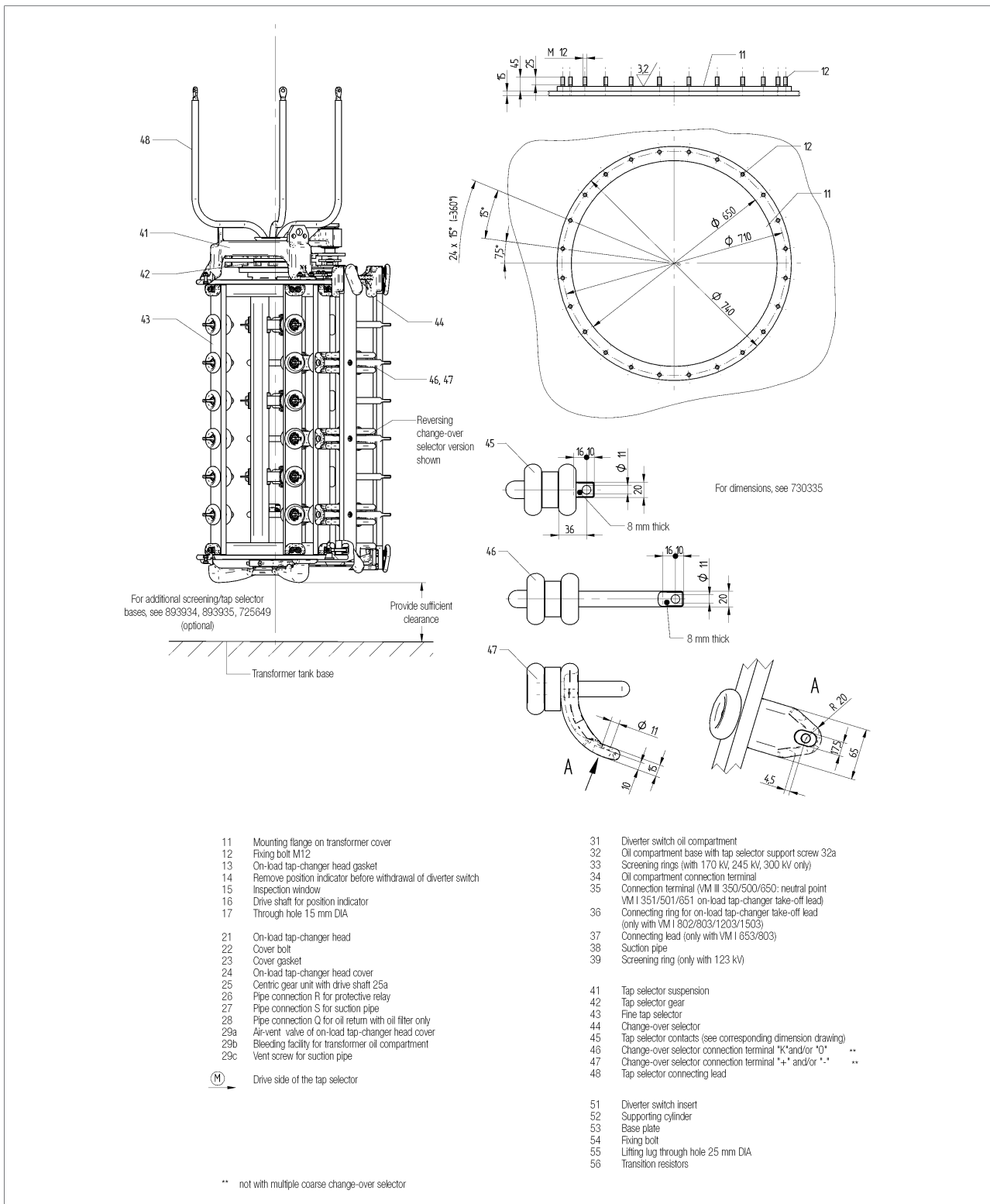
9 Drawings

9.1 VACUTAP® VM, installation drawing (746230)

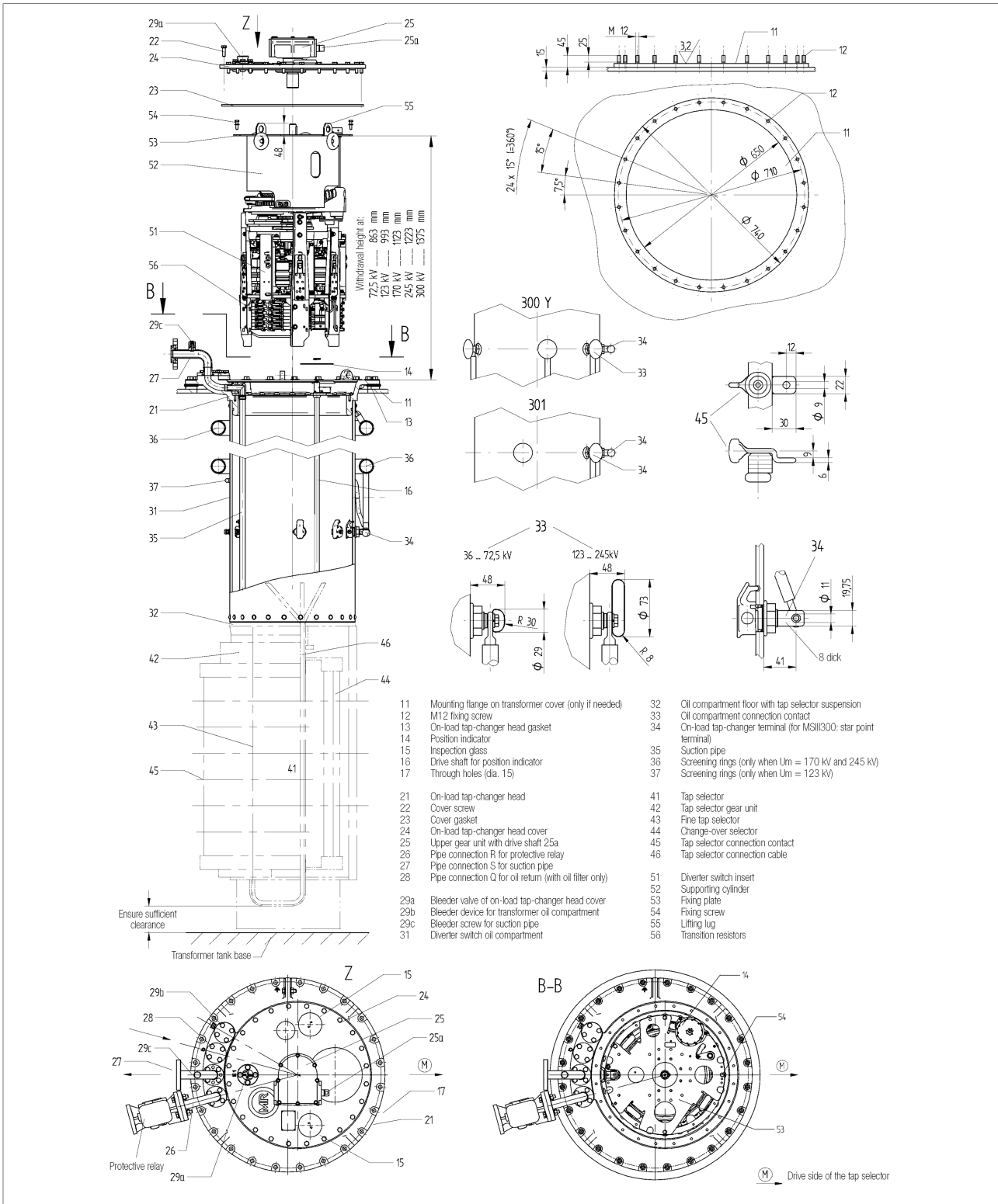




VACUTAP® VM - installation drawing of central drive (746230) –2–

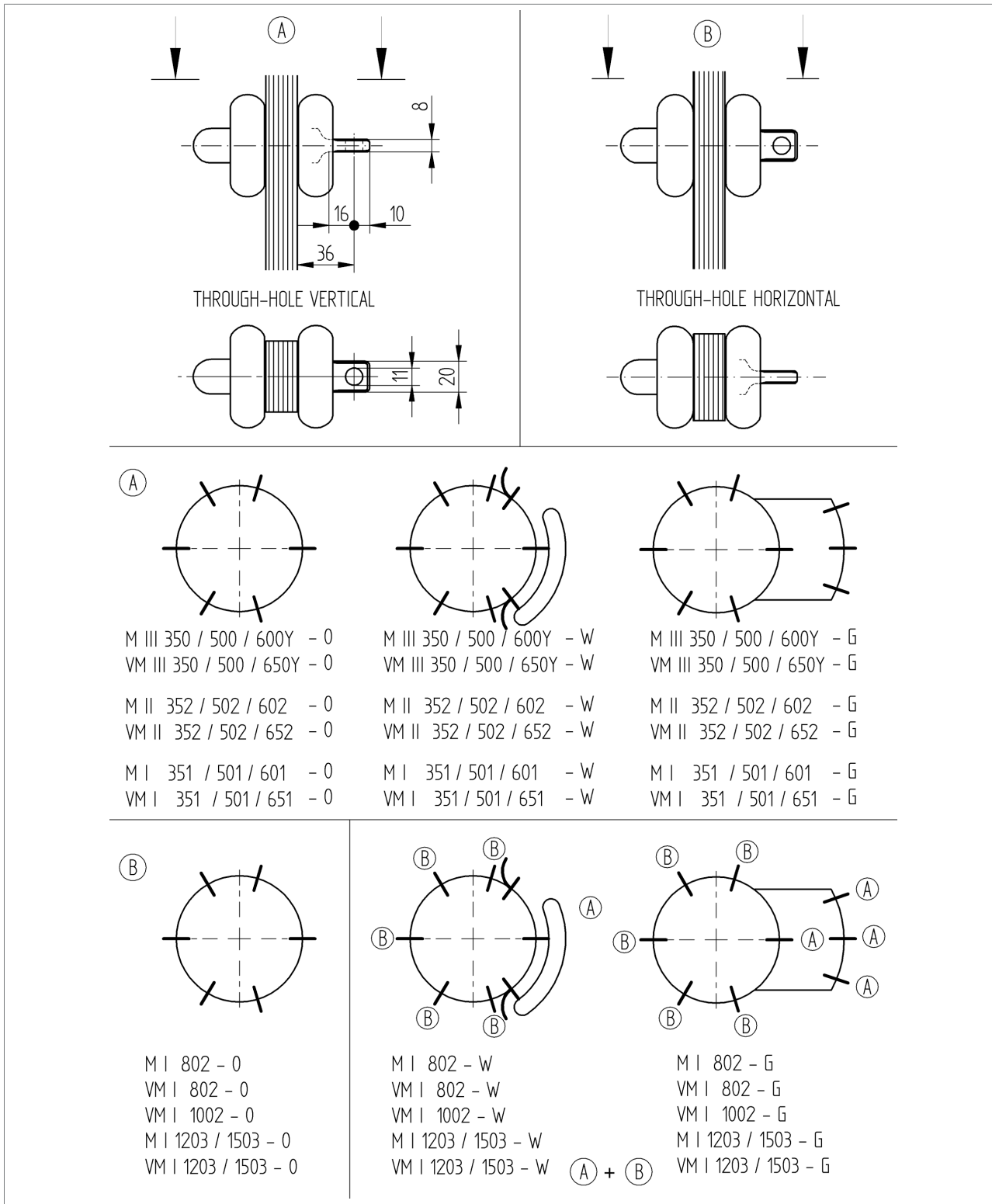


9.2 VACUTAP® VM 300, installation drawing (765192)

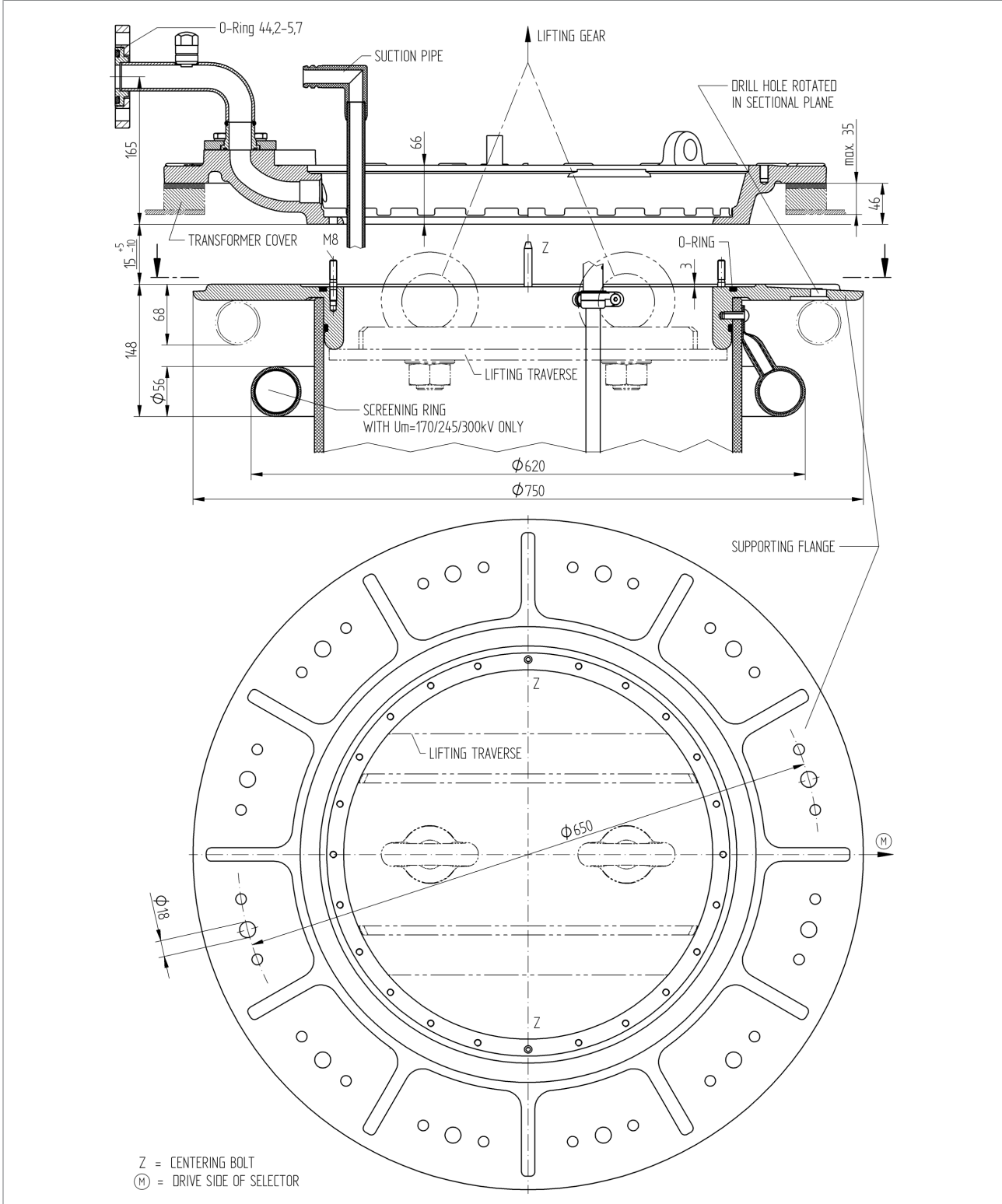




9.3 VACUTAP® VM, installation position of selector connection contacts (890477)

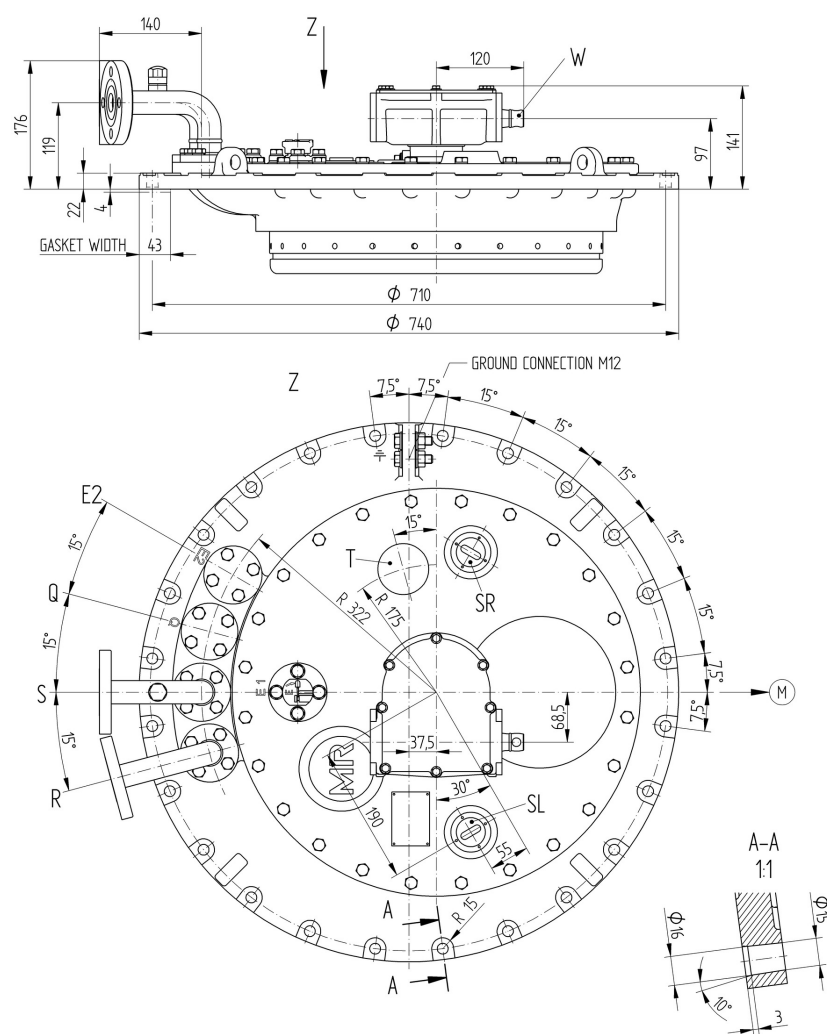


9.4 Special design for bell-type tank installation for Um up to 300 kV (896762)



9.5 On-load tap-changer head (893899)

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DATE	NAME	DOCUMENT NO.
28.04.2014	RAEDLINGER	SED 1661272 001 03
17.06.2014	HAUER	CHANGE NO.
17.06.2014	PRODASTSCHUK	1057233
		SCALE
		1:2,5

- 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:

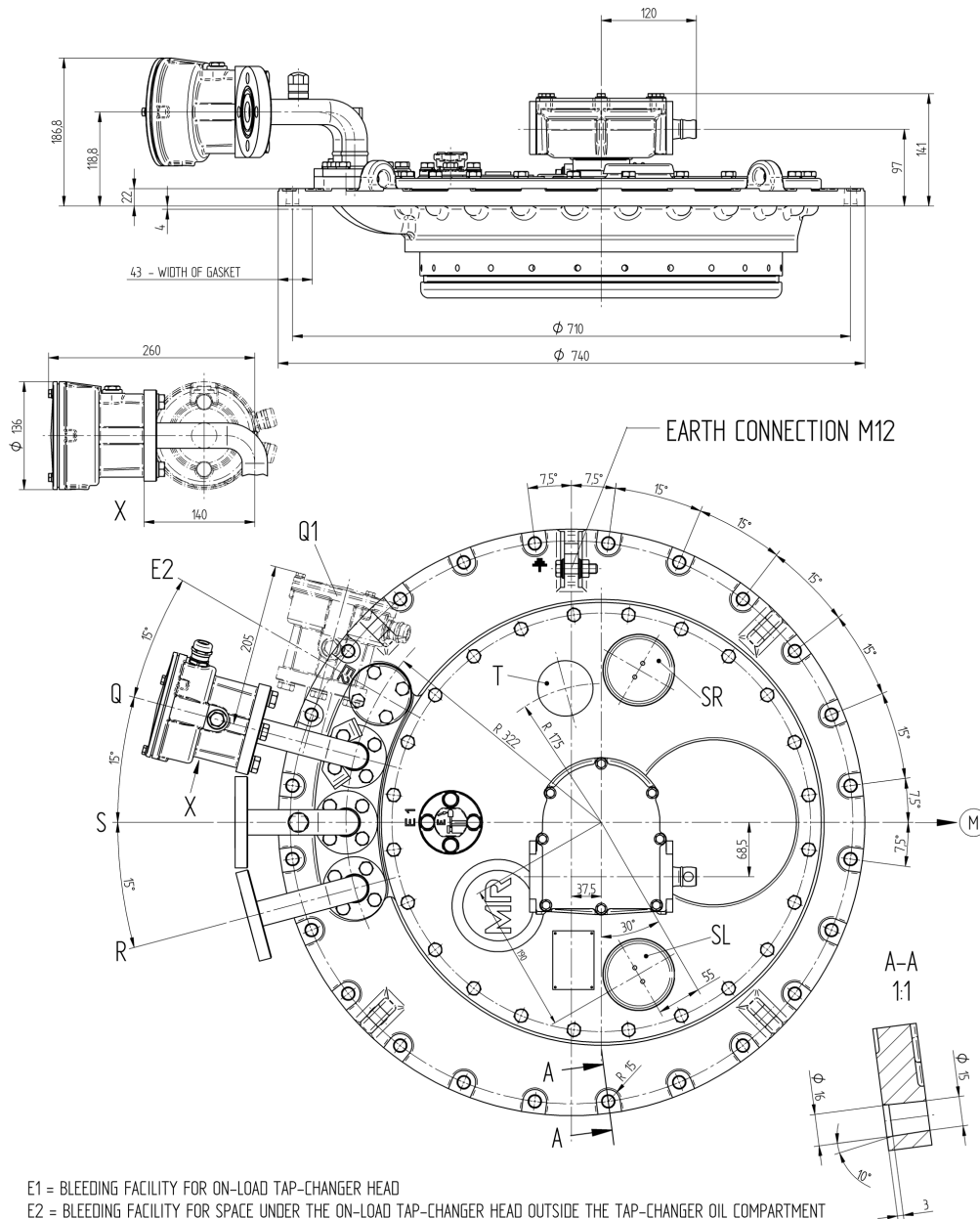
DIMENSION
IN mm
EXCEPT AS
NOTED



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 On-load tap-changer head with tap-change supervisory control (894109)



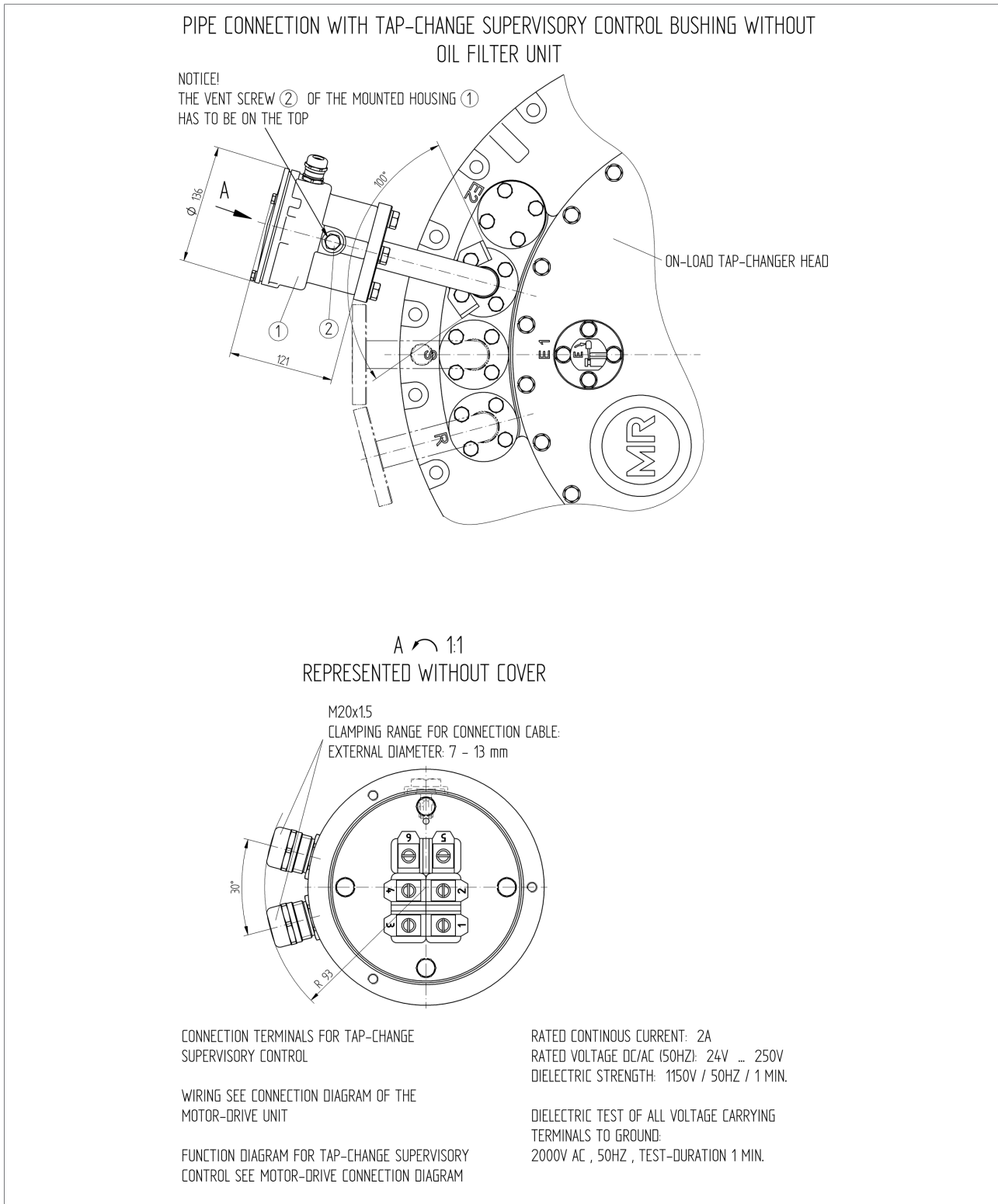
- E1 = BLEEDING FACILITY FOR ON-LOAD TAP-CHANGER HEAD
- E2 = BLEEDING FACILITY FOR SPACE UNDER THE ON-LOAD TAP-CHANGER HEAD OUTSIDE THE TAP-CHANGER OIL COMPARTMENT (OPTIONALLY WITH SAME PIPE CONNECTION AS Q, S, R OR BLEEDER SCREW)
- Q = CONNECTION FOR OIL RETURN PIPE (ONLY FOR OIL FILTER) - CONNECTIONS ORIENTABLE THROUGH 100°
- Q1 = CONNECTION FOR TAP CHANGE SUPERVISORY CONTROL, IF OIL RETURN PIPE OF OIL FILTER SYSTEM IS INSTALLED AT Q - CONNECTIONS ORIENTABLE THROUGH 100°
- S = CONNECTION FOR SUCTION PIPE - CONNECTIONS ORIENTABLE THROUGH 360°
- R = CONNECTION FOR PROTECTIVE RELAY (EXCHANGEABLE WITH CONNECTION Q) - CONNECTIONS ORIENTABLE THROUGH 360°
- T = THERMOMETER BAG (OPTIONALLY)
- SR = INSPECTION WINDOW, RIGHT
- SL = INSPECTION WINDOW, LEFT

SCALE 1: 2,5 (1: 1)

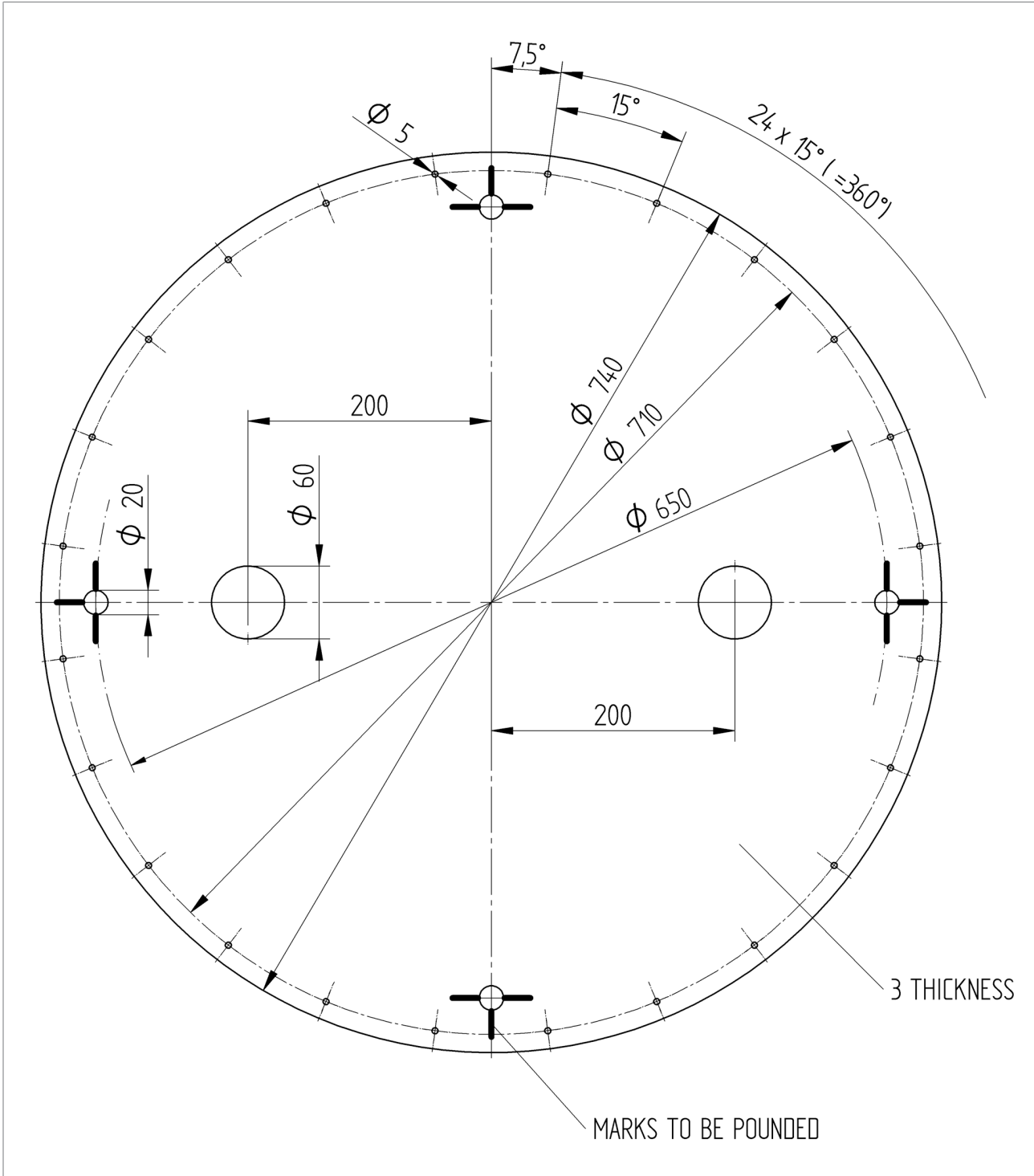
(M) DRIVE SIDE OF THE TAP SELECTOR



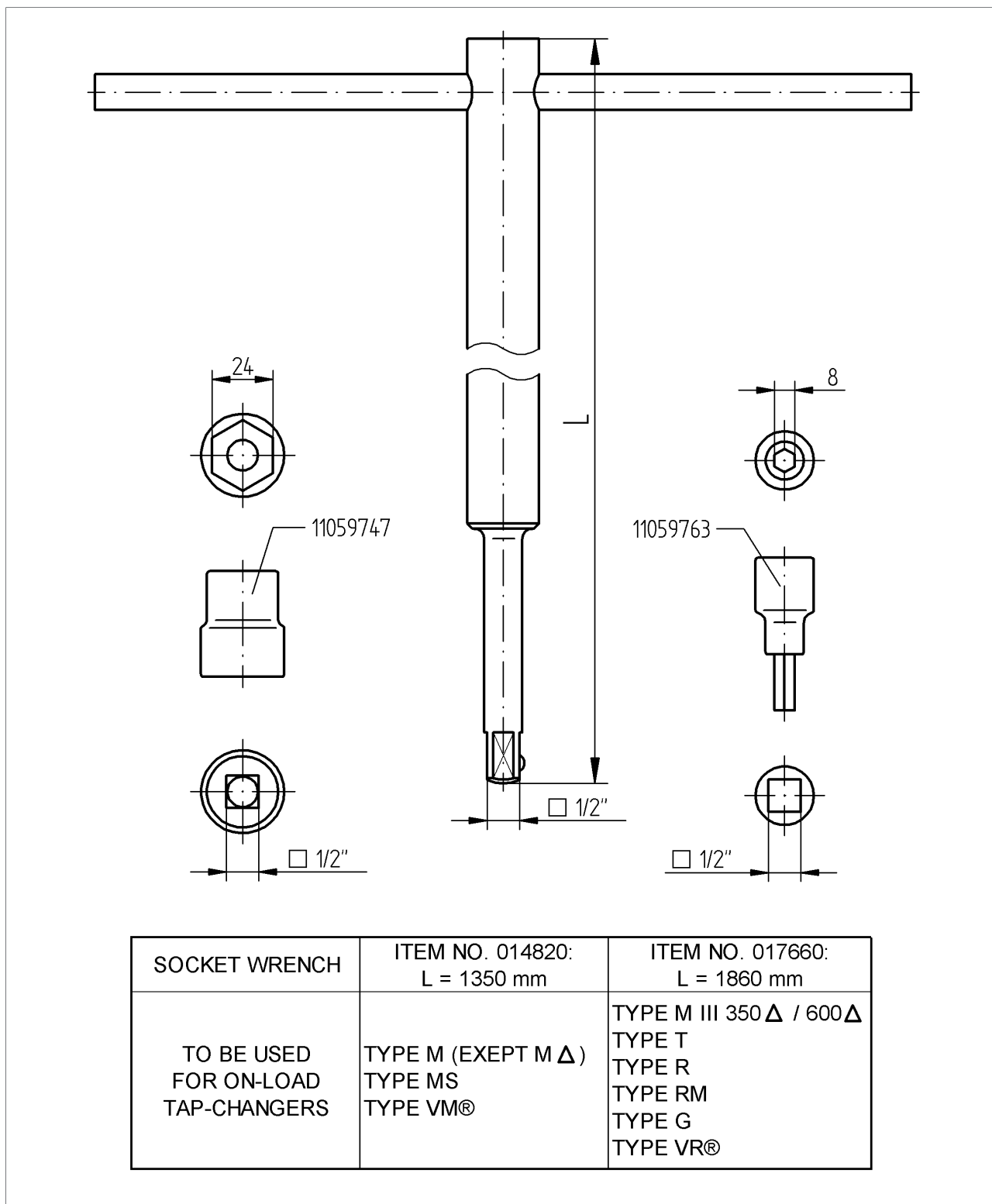
9.7 Pipe connection Q with tap-change supervisory control (766161)



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

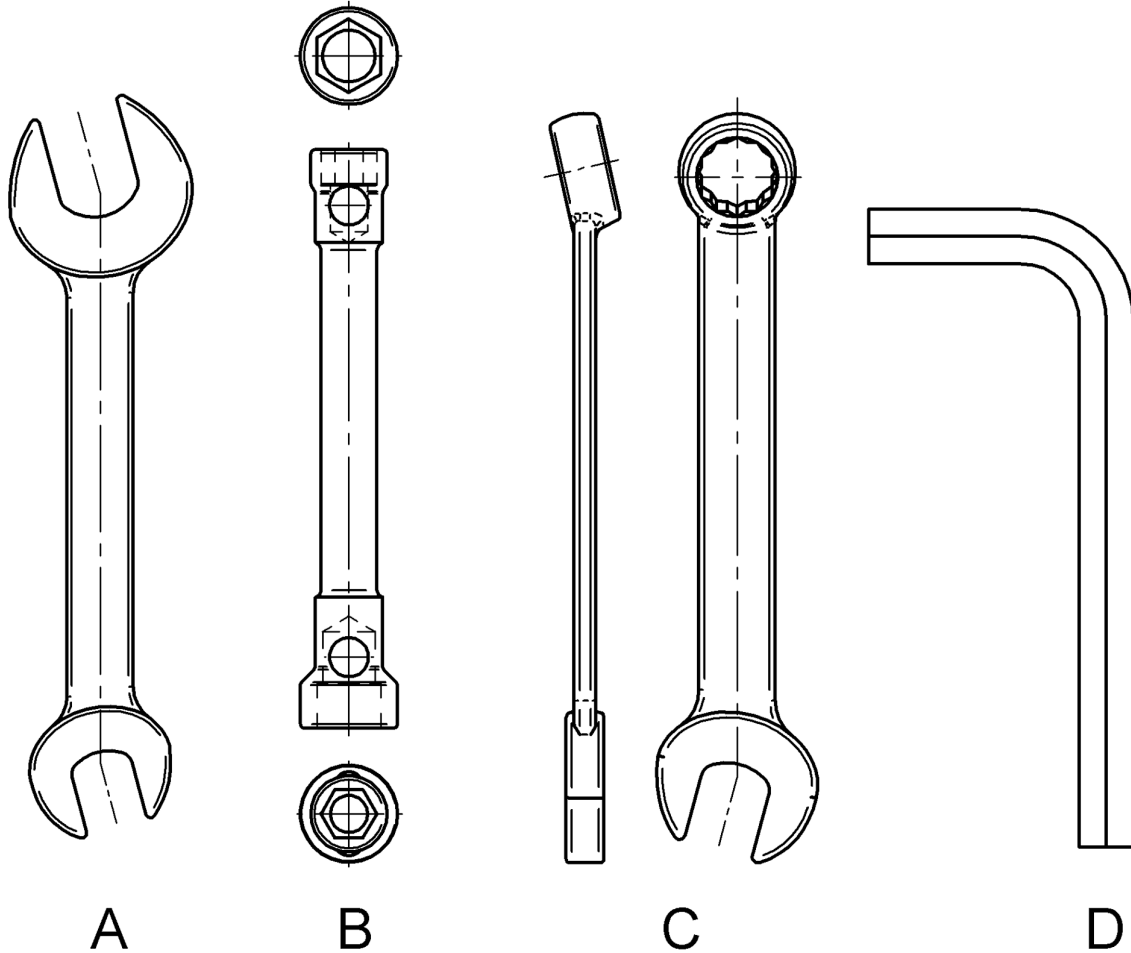


9.9 Socket wrench for kerosene drain plug (890182)



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

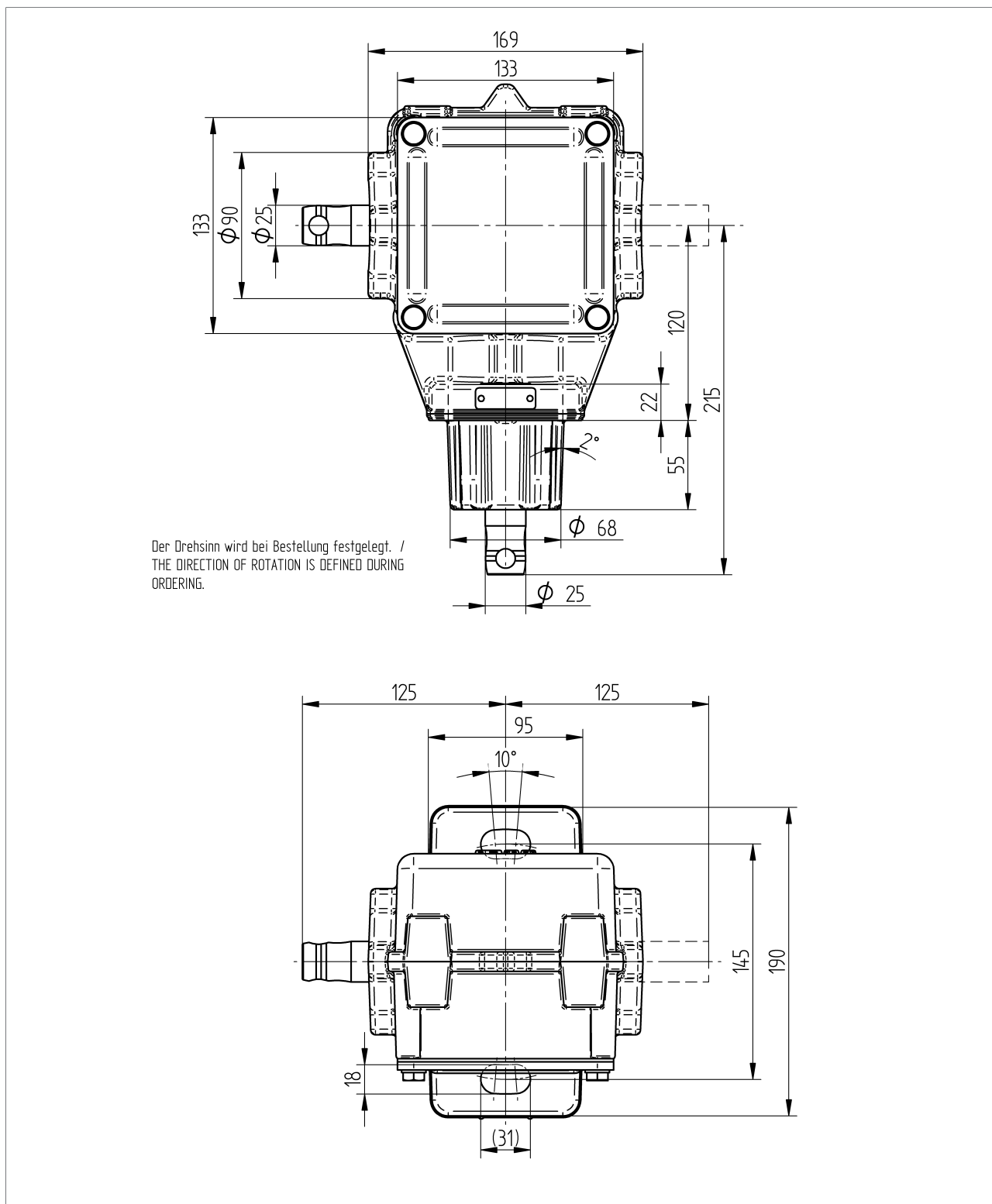
9.10 Screw tools for installation and maintenance (890478)



ITEM	NO.	DESIGNATION	FIG.	DIN	WRENCH SIZE
1	1	DOUBLE-ENDED OPEN-JAW WRENCH	A	895	8 x 10
2	1	RING & OPEN-JAW WRENCH	C	3113	10
3	1	DOUBLE-ENDED OPEN-JAW WRENCH	A	895	13 x 17
4	1	DOUBLE-ENDED SOCKET WRENCH	B	896	13 x 17
5	1	DOUBLE-ENDED OPEN-JAW WRENCH	A	895	17 x 19
6	1	DOUBLE-ENDED OPEN-JAW WRENCH	A	895	22 x 24
7	1	HEXAGON SOCKET SCREW KEY	D	911	4
8	1	HEXAGON SOCKET SCREW KEY	D	911	5
9	1	HEXAGON SOCKET SCREW KEY	D	911	8

ADDITIONAL DRAWING: 890479:
SPECIAL TOOLS FOR THE INSPECTION

9.11 Bevel gear CD 6400, dimensional drawing (892916)





Glossary

DC

Direct current

Dielectric strength

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

IEC

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

IP

Ingress protection

MR

Maschinenfabrik Reinhausen GmbH

NC

Normally Closed contact

NO

Normally Open contact

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www.reinhausen.com

5293069/01 EN - VACUTAP® VM-Ex -

- 08/20 - Maschinenfabrik Reinhausen GmbH 2020

THE POWER BEHIND POWER.

