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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 on the safe and proper installation, connection, commissioning and monitoring of the product. In addition, this file contains technical data for selecting the appropriate product for a respective application. It also includes safety instructions and general information about the product.

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

1.1 Validity

This technical file applies to the VACUTAP® RMV-II on-load tap-changer with the standard position designations 16L...N...16R.

Drawings and illustrations in this technical file are provided for reference only. For specific details please refer to drawings submitted with each individual customer order.

1.2 Manufacturer

This product is manufactured by:

Reinhausen Manufacturing Inc.
2549 North 9th Avenue, 38343 Humboldt, Tennessee, USA
Tel.: +1 731 784 7681
Fax: +1 731 784 7682

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

1.3 Subject to change without notice

The information contained in this technical file comprises the technical specifications approved at the time of printing. Significant modifications will be included in a new edition of the technical file.

The document number and version number of this technical file are shown in the footer.

1.4 Completeness

This technical file is incomplete without the supporting documentation.
1.5 Supporting documents

The following documents also apply in addition to this technical file:

- Technical data and drawings which are provided upon order confirmation and delivery

Also observe generally valid legislation, standards, and guidelines as well as specifications on accident prevention and environmental protection in the respective country of use.

1.6 Safekeeping

This technical file and all supporting documents must be kept ready at hand and accessible for future use at all times.

1.7 Notation conventions

This section contains an overview of the symbols and textual emphasis used.

1.7.1 Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="symbol.png" alt="Wrench size" /></td>
<td>Wrench size</td>
</tr>
<tr>
<td><img src="symbol.png" alt="Tightening torque" /></td>
<td>Tightening torque</td>
</tr>
<tr>
<td><img src="symbol.png" alt="Number and type of fastening materials used" /></td>
<td>Number and type of fastening materials used</td>
</tr>
<tr>
<td><img src="symbol.png" alt="Fill with oil" /></td>
<td>Fill with oil</td>
</tr>
<tr>
<td><img src="symbol.png" alt="Cut open, cut through" /></td>
<td>Cut open, cut through</td>
</tr>
<tr>
<td><img src="symbol.png" alt="Clean" /></td>
<td>Clean</td>
</tr>
<tr>
<td><img src="symbol.png" alt="Visual inspection" /></td>
<td>Visual inspection</td>
</tr>
<tr>
<td><img src="symbol.png" alt="Use your hand" /></td>
<td>Use your hand</td>
</tr>
<tr>
<td><img src="symbol.png" alt="Adapter ring" /></td>
<td>Adapter ring</td>
</tr>
</tbody>
</table>
1 Introduction

---

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apply a coat of paint</td>
</tr>
<tr>
<td></td>
<td>Use a file</td>
</tr>
<tr>
<td></td>
<td>Grease</td>
</tr>
<tr>
<td></td>
<td>Coupling bolt</td>
</tr>
<tr>
<td></td>
<td>Use a ruler</td>
</tr>
<tr>
<td></td>
<td>Use a saw</td>
</tr>
<tr>
<td></td>
<td>Hose clip</td>
</tr>
<tr>
<td></td>
<td>Wire eyelet, safety wire</td>
</tr>
<tr>
<td></td>
<td>Use a screwdriver</td>
</tr>
</tbody>
</table>

Table 1: Symbols

1.7.2 Hazard communication system

Warnings in this technical file are displayed as follows.

1.7.2.1 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 and source of danger

Consequences

► Action

► Action
1.7.2.2 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.

1.7.2.3 Signal words and pictograms

The following signal words are used:

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

Table 2: Signal words in warning notices

Pictograms warn of dangers:

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

Table 3: Pictograms used in warning notices
1.7.3 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.
2 Safety

2.1 General safety information

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

- Read this technical file through carefully to familiarize yourself with the product.
- Particular attention should be paid to the information given in this chapter.

2.2 Appropriate use

The product and associated equipment and special tools supplied with it comply with the relevant legislation, regulations and standards, particularly health and safety requirements, applicable at the time of delivery.

If used as intended and in compliance with the specified requirements and conditions 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 hazards to people, property or the environment. This applies throughout the product’s entire life, from delivery through installation and operation to disassembly and disposal.

The operational quality assurance system ensures a consistently high quality standard, particularly in regard to the observance of health and safety requirements.

The following is considered appropriate use

- Only operate the product in accordance with this technical file and the agreed delivery conditions and technical data
- Use the equipment and special tools supplied solely for the intended purpose and in accordance with the specifications of this technical file
- Use the product only with the transformer specified in the order
- The serial numbers of the on-load tap-changer and drive must match.

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

Danger of death or severe injury and damage to property and the environment!

Danger of death or severe injury and damage to property and the environment due to electrical voltage, falling and/or tipping parts as well as dangerous cramped conditions resulting from moving parts!

- Adherence to the following prerequisites and conditions is mandatory.
- Adhere to warning notices.
The on-load tap-changer is dimensioned as per IEC 60214-1:2003 and ANSI/IEEE C57.131:2012 and can therefore switch currents of up to twice the value of the rated through current.

On-load tap-change operations are not to be performed during operating conditions with higher currents.

Examples of such operating conditions are:
• Inrush current impulses when transformers are switched on
• Short circuit

The rated step voltage may be briefly exceeded by up to 10 % as long as the rated through current is not exceeded. Such an operating condition can occur due to overexcitation of the transformer after load shedding, for example.

In its standard version, the on-load tap-changer can be operated in the temperature range of the surrounding transformer oil of between -25 °C and +100 °C.

On request, a version for Arctic operation is also available, which can be used down to a minimum ambient temperature of -40 °C.

2.3 Inappropriate use

Use is considered to be inappropriate if the product is used other than as described in the Appropriate use section.

Reinhausen Manufacturing does not accept liability for damage resulting from unauthorized or inappropriate changes to the product. Inappropriate changes to the product without consultation with Reinhausen Manufacturing can lead to personal injury, damage to property and operational disruption.

2.4 Personnel qualification

The product is designed solely for use in electrical energy systems and facilities operated by appropriately trained staff. This staff comprises people who are familiar with the installation, assembly, commissioning and operation of such products.

2.5 Operator’s duty of care

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:
• All warning and hazard notices are complied with.
• Personnel are instructed regularly in all relevant aspects of operational safety, the operating instructions and particularly the safety instructions contained therein.
2 Safety

- Regulations and operating instructions for safe working as well as the relevant instructions for staff procedures in the case of accidents and fires are kept on hand at all times and are displayed in the workplace where applicable.
- The product is only used when in a sound operational condition and safety equipment in particular is checked regularly for operational reliability.
- Only replacement parts, lubricants and auxiliary materials which are authorized by the manufacturer are used.
- The specified operating conditions and requirements of the installation location are complied with.
- All necessary devices and personal protective equipment for the specific activity are made available.
- The prescribed maintenance intervals and the relevant regulations are complied with.
- Installation, electrical connection and commissioning of the product may only be carried out by qualified and trained personnel in accordance with this technical file.
- The operator must ensure appropriate use of the product.

2.6 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.
- Follow information about personal protective equipment provided in the work area.

<table>
<thead>
<tr>
<th>Always wear</th>
<th>Protective clothing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Close-fitting work clothing with a low breaking strength, with tight sleeves and with no protruding parts. It mainly serves to protect the wearer against being caught by moving machine parts. Do not wear any rings, necklaces or other jewelry.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Always wear</th>
<th>Safety shoes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To protect against falling heavy objects and slipping on slippery surfaces.</td>
</tr>
</tbody>
</table>

Table 4: Personal protective equipment to be worn at all times
Special personal protective equipment is needed in special environments. The choice of equipment depends on the circumstances.

<table>
<thead>
<tr>
<th>Wear the following in special environments</th>
<th>Special personal protective equipment is needed in special environments. The choice of equipment depends on the circumstances.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety glasses</td>
<td>Safety glasses To protect the eyes from flying parts and splashing liquids.</td>
</tr>
<tr>
<td>Hard hat</td>
<td>Hard hat To protect from falling and flying parts and materials.</td>
</tr>
<tr>
<td>Hearing protection</td>
<td>Hearing protection To protect from hearing damage.</td>
</tr>
</tbody>
</table>

Table 5: Personal protective equipment to be worn in special environments

2.7 Protective devices

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

2.7.1 Pressure relief device MPreC®

For detailed information about the pressure relief device, please refer to the relevant operating instructions.

Ensure that the relevant circuit breaker immediately de-energizes the transformer as soon as the pressure relief device or any other protective device triggers. To do this, loop one signaling contact into the tripping circuit of the circuit breaker for each protective device.

2.7.2 Protective devices in the motor-drive unit

The following protective devices are fitted in the motor-drive unit:

- End stop device (mechanical and electric)
- Device protecting against unintentional passage
- Motor protection device
- Protection against accidental contact
- Electronics of monitoring system to monitor the vacuum interrupters in the on-load tap-changer
3 Product description

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

3.1 On-load tap-changer

3.1.1 Function description for on-load tap-changer

RMV-II on-load tap-changers are used in conjunction with oil-immersed power transformers, regulating transformers and phase shifter transformers to change taps under load thereby controlling voltage magnitude or phase angle.

The RMV-II on-load tap-changer follows the switching concept of a preventive auto transformer (reactor). Vacuum interrupters are used to interrupt the circuit within a half cycle. The interrupt occurs in the vacuum, so there is no shutdown arc in the oil and therefore no contamination of the oil.

The diagram below shows a typical winding arrangement with the on-load tap-changer in operating position 16L:
### 3 Product description

![Diagram of on-load tap-changer](image-url)

**Figure 1:** Typical winding arrangement of on-load tap-changer (example: operating position 16L)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B</td>
<td>Main switching contacts of change-over selector (example: reversing change-over selector)</td>
</tr>
<tr>
<td>M</td>
<td>Central position contact</td>
</tr>
<tr>
<td>3, 4, ... 12</td>
<td>Stationary change-over selector contacts (interface to the tap leads of the tapped winding)</td>
</tr>
<tr>
<td>P₁, P₄</td>
<td>Mobile change-over selector contacts</td>
</tr>
<tr>
<td>VI</td>
<td>Vacuum interrupter</td>
</tr>
<tr>
<td>P₂, P₃</td>
<td>Main switching contacts for by-pass switch</td>
</tr>
<tr>
<td>P</td>
<td>Take-off terminal</td>
</tr>
</tbody>
</table>

The tap changer operation is divided into three major functions:

1. Arc interruption and reclosing using the vacuum interrupters in conjunction with the associated by-pass switches P₂ and P₃
2. Selection of the next tap position by the tap selector assemblies in the correct order with actuation of the vacuum interrupters and by-pass switches
3. Operation of change-over selector (reversing change-over selector connection or coarse/fine selector) in order to double the number of tap positions

The example below shows the process when changing the operating position from 16L to 15L:
The tap changer is operated using a motor-drive unit.

When moving from one tap position to the next, firstly a by-pass switch (in the example P₁) opens, while the second (P₂) stays closed, routing the current through the vacuum interrupter just prior to its operation.

The vacuum interrupter opens by a spring-operated mechanism before the mobile fine tap selector contact (in the example P₄) selects the next tap.

The vacuum interrupter then closes due to spring force and locks. The by-pass switch closes again, completing the tap-change operation.

The tap selector connects the preventive auto transformer alternately into a bridging or a non-bridging position. The change-over selector operates only when changing from position 1 L to N or N to 1 L.

For more details on the operating positions, please refer to the order-specific technical files that you received with the order confirmation.
### 3.1.2 On-load tap-changer design

The RMV-II on-load tap changer is a three-phase on-load tap-changer with full insulation between phases and to ground. The on-load tap-changer comprises:

- Tank with tap selector and change-over selector (reversing change-over selector connection or coarse/fine selector connection)
- By-pass switch
- Vacuum interrupters with monitoring system
- Motor-drive unit
- Dehydrating breather

All switching elements involved in the tap-change operation, selectors and change-over selectors, vacuum interrupters and by-pass switches of all phases, are driven by one main shaft from the drive mechanism.

![Figure 3: On-load tap-changer oil compartment](image)

One vertical insulating plate per phase is permanently mounted on the top of the on-load tap-changer oil compartment. The vacuum interrupter is mounted vertically on the front of the insulating plate.
The by-pass switch is located on the opposite (rear) side of the insulating plate from the vacuum interrupter and is driven by the same drive shaft. The by-pass switch consists of two contact assemblies with parallel spring-loaded contact fingers.

Each phase of the on-load tap-changer also consists of a tap selector and change-over selector, which are fitted on the rear of the on-load tap-changer oil compartment on an epoxy terminal board.
3 Product description

Depending on the operating voltage of the on-load tap-changer, there are two different terminal board models.

Figure 6: Terminal board

Figure 7: RMV-II 15 kV and RMV-II 26.4 kV terminal board
3.1.2.1 Name plate

The on-load tap-changer’s name plate is located on the door of the on-load tap-changer oil compartment.

3.1.3 Performance features

The on-load tap-changer is particularly characterized by the following properties:

- No arcing in the insulating oil
- Long lifespan of the insulating oil
- Virtually maintenance-free
- Low operating costs
3 Product description

3.1.4 Scope of delivery

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

- Oil compartment with in-built on-load tap-changer, tap selector and change-over selector
- The oil compartment is equipped with:
  - Oil drain valve with 2" thread for customer connection and fixture for taking oil samples
  - Vacuum connection: 2" half-coupling
  - Filler: 1" half-coupling
  - Terminal board with connecting lugs, each prepared with two 0.625" bores (without thread) for the customer's connection
- Pressure relief device MPrec
- Technical files

Please note the following:

- 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.

3.2 Motor-drive unit

The brief description provided in this chapter is no substitute for the motor-drive unit's operating instructions. For detailed operation and safety information please read carefully through the operating instructions for the MD-III motor-drive unit.

3.2.1 Function description of motor-drive unit

The motor-drive unit adjusts the operating position of on-load tap-changers in regulating transformers to the individual operating requirements.

The tap-change operation is activated by starting the motor-drive unit (a single control impulse triggered, for example, by a voltage regulator of the TAPCON®-series). This operation is always completed regardless of any other control pulses emitted during the tap-change operation. In the standard design, the next tap-change operation can only proceed once all control devices have reached their rest positions.

Behavior in the event of a voltage interruption

Should the voltage be interrupted during an on-load tap-change operation, once the voltage supply returns, the motor-drive unit completes the started on-load tap-change operation.
3.2.2 Motor-drive unit design

The actual motor-drive unit equipment and the arrangement of devices may differ from that shown.

![Diagram of MD-III motor-drive unit without doors](image)

**Figure 9: View of MD-III motor-drive unit without doors**

|   |   |   |   |   | 1 Name plate | 2 Motor protective switch 8-2 | 3 Circuit breaker (optional) | 4 VIM-OK signal lamp (86GL) | 5 Alarm signal lamp (86RL) | 6 LOCAL/REMOTE rotary switch | 7 RAISE/LOWER rotary switch | 8 Snap lock | 9 Swing frame | 10 Hand lamp | 11 Voltage regulator (optional) | 12 Transmission gear cover plate | 13 Monitoring circuit board | 14 Indication field | 15 Hand crank aperture with guide lever | 16 Hand crank |

3.3 Monitoring system (VIM)

The monitoring system is also known as the VIM module (Vacuum Interrupter Monitoring). A brief description of the monitoring system can be found in this chapter.

This chapter is no substitute for the detailed information provided in the separate operating instructions.
For detailed operation and safety information on the monitoring system, please read carefully through the operating instructions for the MD-III operating instructions.

### 3.3.1 Function description of monitoring system

**WARNING**

**Danger of death, severe injury and damage to property!**

Danger of death, severe injury and damage to property due to incorrect operation of hand crank and monitoring system!

- Never actuate on-load tap-changer with the hand crank if the transformer is energized. When the hand crank is operated, the monitoring system no longer provides protection so failure of a vacuum interrupter may result in injuries to operating staff and/or damage to the transformer.

- Check the on-load tap-changer when the monitoring system trips during operation.

- Before resetting the monitoring system, always first establish the cause and remedy the fault.

- The monitoring system improves operating reliability, but cannot cover all operating statuses.

There is a high probability that the monitoring system will detect a vacuum interrupter malfunction in the following operating modes:

- Electric on-load tap-change operation resulting from manual actuation of the RAISE/LOWER pivot switch
- Electric on-load tap-change operation resulting from automatic activation by a voltage regulator

If the hand crank is operated, the monitoring system does not provide protection.

An optional mechanical hand crank lock can be used to block the hand crank in cases where the monitoring system reports a fault or is not ready for operation.

In the event of an error, the monitoring system triggers the following actions:

- The on-load tap-changer is stopped and returned to its starting position
- The motor protective switch 8-2 is tripped
- Further electrical on-load tap-change operations are blocked
- In designs with an appropriate hand crank lock: Hand crank operations are also blocked
- The error indication on the monitoring circuit board lights up
  - Yellow LED for errors in the signal transmission
  - Red LED for errors in a vacuum interrupter
- Error messages are indicated by illumination of the red **Alarm** signal lamp (86RL) on the swing frame of the motor-drive unit.
3.3.2 Monitoring system displays and controls

The following displays and controls of the monitoring system (Vacuum Interrupter Monitoring VIM) are located behind the motor-drive unit's door:

- The green TEST push-button is used to check the internal circuitry of the monitoring system.
- 1 green LED indicates the control voltage supply present
- 3 red LEDs (1 per phase) indicate when a vacuum interrupter malfunction has been recorded
  - The monitoring system performs this check during every diverter switch operation
- 3 yellow LEDs (1 per phase) indicate the loss of the current transformer signal
  - The monitoring system repeats this check after every 32 tap-change operations
- The red RESET push-button has to be pressed to reactivate the monitoring system after a check

3.4 Dehydrating breather

The dehydrating breather removes moisture from the air breathed into the on-load tap-changer. The dehydrating breather comprises:

- Glass cylinder
- Connecting flange on top
- Breather
- Protective grate with viewing windows

By way of an option, we recommend using the maintenance-free MTraB® DB 100 dehydrating breather from Maschinenfabrik Reinhausen GmbH.
Upon delivery
The breather is supplied dismantled with the drying agent placed in separate containers.
4 Packaging, transport and storage

4.1 Packaging

The products are sometimes supplied with a sealed packaging and sometimes also dried depending on what is required.

A sealed packaging surrounds the packaged goods on all sides with plastic foil. Products that have also been dried are identified by a yellow label on the sealed packaging.

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

4.1.1 Suitability

**NOTICE**

Property damage due to incorrectly stacked crates!

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

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

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

The packaged goods are packed in a stable crate. This crate ensures that the packaged goods are secure when in the intended transportation position and that none of the parts touch the loading surface of the means of transport or touch the ground after unloading.

The packaged goods are stabilized inside the crate to prevent impermissible changes in position.

A sealed packaging surrounds the packaged goods on all sides with plastic foil. The packaged goods are protected from humidity using a desiccant. The plastic foil is bonded after the drying agent is added.

4.1.2 Markings

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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protect against moisture</td>
<td>Top</td>
</tr>
<tr>
<td>Fragile</td>
<td>Attach lifting gear here</td>
</tr>
<tr>
<td>Center of mass</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Shipping pictograms
4.2 Transportation, receipt and handling of shipments

**WARNING**
Danger of death and damage to property!

- Transport crate only when closed.
- Do not remove the mounting material used in the crate during transport.
- Only trained and appointed persons may select the sling gear and secure the load.
- Do not walk under the hanging load.
- Use means of transport and lifting gear with a sufficient carrying capacity in accordance with the weight stated on the delivery slip.

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

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

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

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

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

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

- Immediately record the transport damage found in the shipping documents and have this countersigned by the carrier.
- In the event of severe damage, total loss or high damage costs, immediately notify the sales department at Maschinenfabrik Reinhausen and the relevant insurance company.
- After identifying damage, do not modify the condition of the shipment further and retain the packaging material until an inspection decision has been made by the transport company or the insurance company.
- Record the details of the damage immediately onsite together with the carrier involved. This is essential for any claim for damages!
- Photograph damage to packaging and packaged goods. This also applies to signs of corrosion on the packaged goods due to moisture inside the packaging (rain, snow, condensation).
- **NOTICE!** Be absolutely sure to also check the sealed packaging. If the sealed packaging is damaged, do not under any circumstances install or commission the packaged goods. Either dry the dried packaged goods again as per the operating instructions for the relevant on-load tap-
4 Packaging, transport and storage

changer/off-circuit tap-changer or contact Maschinenfabrik Reinhausen
GmbH to agree on how to proceed with drying. If this is not done, the
packaged goods may be damaged.

- Name the damaged parts.

**Hidden damage**

When damages are not determined until unpacking after receipt of the ship-
ment (hidden damage), proceed as follows:

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

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

### 4.3 Storage of shipments

**Packaged goods dried by Maschinenfabrik Reinhausen**

Upon receipt of the shipment, immediately remove the packaged goods
dried by Maschinenfabrik Reinhausen from the sealed packaging and store
air-tight in dry insulating oil until used.

**Non-dried packaged goods**

Non-dried packaged goods but with a functional sealed packaging can be
stored outdoors when the following conditions are complied with.

When selecting and setting up the storage location, ensure the following:

- Protect stored goods against moisture (floodling, water from melting
snow and ice), dirt, pests such as rats, mice, termites and so on, and
against unauthorized access.
- Store the crates on timber beams and planks as a protection against ris-
ing damp and for better ventilation.
- Ensure sufficient carrying capacity of the ground.
- Keep entrance paths free.
- Check stored goods at regular intervals. Also take appropriate action af-
ter storms, heavy rain or snow and so on.

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

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

- Correctly regenerate the drying agent and restore the sealed packaging.
4 Packaging, transport and storage

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

4.4 Unpacking shipments and checking for transportation damages

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

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

- Check completeness of supplementary parts on the basis of the delivery slip.

4.5 Things to note when putting back into storage

The on-load tap-changer is shipped from Reinhausen Manufacturing filled with dry nitrogen under positive pressure.

**NOTICE**

**Damage caused by storage in unheated buildings or outdoors**

If the on-load tap-changer and drive are to be stored in unheated buildings or outdoors:

- Fill on-load tap-changer tank with clean, dry oil and refill gas space with dry nitrogen to a maximum pressure of 0.275 bar (4 psi).

- Weather-proof outside of tank and terminal board.

- Heat drive by connecting the built-in space heater to power.

After opening the on-load tap-changer, if it is to be stored again in closed rooms: Rinse the on-load tap-changer’s oil compartment and refill with dry nitrogen to a pressure of no more than 0.275 bar (4 psi).
5 Fitting on-load tap-changer on transformer

This chapter describes how to fit the on-load tap-changer to a transformer.

5.1 Preparatory work

Perform the work stated below before fitting the on-load tap-changer to the transformer:

- Before mounting on the transformer, open the on-load tap-changer's oil compartment and the drive mechanism air compartment and inspect for damage which may have occurred in shipment due to rough handling.
- If shipment damage is found, immediately raise a complaint with the supplier and inform Reinhausen Manufacturing.
- Note the general information about the transformer.

5.2 Fitting the on-load tap-changer

**NOTICE**

Damage to the on-load tap-changer caused by heat when welding!

Welding adjacent to the epoxy terminal board may distort its mounting surface and cause damage to the terminal board or its oil seal.

- Use suitable shielding to protect components near welding from radiant heat.

1. Check the size of the opening in the transformer's main tank. For minimum tank opening dimensions, see order-specific dimensional drawing.
2. Weld on-load tap-changer oil compartment onto transformer's main tank. Ensure the welded seam is oil-tight, pressure-tight and vacuum-proof.

Mount the on-load tap-changer on a transformer tank wall that is designed to withstand normal test and operating pressures (at least 15 psi (1 bar)). A 0.25" oil-tight welded seam is required around the outside perimeter of the on-load tap-changer mounting flange. No welded seam is required on the transformer side of the on-load tap-changer.
5.3 Connecting tap winding and on-load tap-changer take-off lead

**NOTICE**

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

Connecting leads which place mechanical strain on the on-load tap-changer will damage the on-load tap-changer!

► Establish and secure connections with care.
► Connect connecting leads to tap selector without warping or deforming.
► If necessary use an expansion loop for connecting leads.

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

6.1 Preparatory work

**WARNING**

The motor-drive unit may be started by accident if the motor protective switch is not tripped!
Risk of injury from starting the motor-drive unit by accident!

- Trip motor protective switch before starting to fit the drive shafts!

**NOTICE**

Damage to on-load tap-changer and motor-drive unit due to incorrect operation!

The on-load tap-changer and motor-drive unit are shipped on separate pallets in the neutral position. Prior to assembly check the serial numbers of the on-load tap-changer and motor-drive unit to ensure they belong together.

If the on-load tap-changer and motor-drive unit are not connected, mechanical damage will result from both the drive shaft of the on-load tap-changer turning and the output shaft of the motor-drive unit turning!

- Prior to shipment the on-load tap-changer is locked in the neutral position by a cotter pin. This cotter pin is inserted through the hub and drive shaft extension on the bottom of the tank. It may only be removed just before assembly. Keep the cotter pin.
- Check the neutral position on the on-load tap-changer and motor-drive unit as described below.
- Only join shafts that have been perfectly aligned.
- If you detect deviations, contact Reinhausen Manufacturing.
Checking neutral position

Check the on-load tap-changer's neutral position with the door open as follows:

1. Both change-over selector contacts are in the top position.

Figure 11: Change-over selector contacts
2. The adjustment markings on the by-pass switch are aligned to one another.

Figure 12: Adjustment markings on the by-pass

Check the motor-drive unit's neutral position as follows:

1. The tap position indicator [1] is at neutral.
2. The pointer on the tap-change indicator [3] is in the mid-position of the area marked in gray.

Figure 13: Indication field
Assembly variants

When assembling the motor-drive unit, a distinction is made between 2 variants:

1. Standard assembly means that the motor-drive unit is fitted directly beneath and secured to the on-load tap-changer.

2. Offset assembly (assembly on the floor) means that there is a gap between the motor-drive unit and the on-load tap-changer beneath which it is fitted and that the motor-drive unit is secured to the transformer on the main tank. This variant requires a mounting support on the main transformer tank, which is provided by the transformer manufacturer.

6.2 Fitting motor-drive unit to on-load tap-changer

For detailed information on fitting and the electrical connection, please refer to the motor-drive unit’s operating instructions.
7 Checks after assembly

Please contact Reinhausen Manufacturing if any aspect of the tests is not clear.

7.1 Manual check

For the manual check, open the on-load tap-changer oil compartment and motor-drive unit. Three insulating material plates are arranged vertically next to one another in the front of the on-load tap-changer oil compartment. The vacuum interrupters are each mounted on the front of the insulating material plates. The by-pass switches are on the rear of the insulating material plates. The tap selector and change-over selector are fitted in the rear section of the oil compartment on the epoxy terminal board, see On-load tap-changer design [► 19] chapter.

1. Switch off motor protective switch 8-2.
2. Insert hand crank in hand crank aperture on motor-drive unit.
3. Use hand crank to switch from Neutral N to 1L. To do this, turn the hand crank counter-clockwise 7.5 revolutions. Check how the on-load tap-changer is undertaking tap changes (the changeover takes place synchronously in all three phases):
   - First, the by-pass switch P₂ has to open, then the vacuum interrupter opens.
   - The tap selector contact P₁ (closest to the terminal board) now moves from M to 11. At the same time, the change-over selector moves from B to A. Make sure that the mobile contacts of the tap selector and change-over selector run smoothly and freely.
   - Next, the vacuum interrupter contact closes again.
   - Lastly, observe closure of the by-pass switch P₂. Once the 7.5 hand crank revolutions are complete, the on-load tap-changer's changeover to the new operating position 1L is complete.
4. Now use the hand crank to switch back into Neutral (N).
   - The switching processes should take place in the order outlined above except that the tap selector moves from 11 to M and the change-over selector moves from A to B.
The same check now has to be performed in the other switching direction.

1. Use hand crank to switch from operating position N to 1R. Again check how the on-load tap-changer undertakes the tap change:
   - First the by-pass switch P₃ and then the vacuum interrupter must open.
   - The tap selector contact P₄ (furthest away from the terminal board) now moves from M to 4. The change-over selector does not move this time. Ensure that the tap selector's mobile contact is again running smoothly and freely.
   - Next, the vacuum interrupter contact closes again.
   - Lastly, observe closure of the by-pass switch P₃. Once the 7.5 hand crank revolutions are complete, the on-load tap-changer's change-over to the new operating position 1R is complete.

2. Now use the hand crank to switch back into Neutral (N).
   - The switching processes should take place in the order outlined above except that the tap selector moves from 4 to M.

3. Withdraw the hand crank and place it in the storage holder provided.
4. Close protective housing of the motor-drive unit.
5. Close oil compartment of the on-load tap-changer.

Tighten nuts on access door to on-load tap-changer to a maximum tightening torque of 11 ft·lb (15 Nm)).

### 7.2 Checking motor-drive unit and monitoring system

Before further checks on the on-load tap-changer and transformer, check that the motor-drive unit and monitoring system are functioning correctly.

A detailed description of this can be found in the operating instructions for the motor-drive unit.

### 7.3 Transformer ratio test and DC resistance measurement

**NOTICE**

Damage to the on-load tap-changer!

Performing too many operations without complete oil filling will damage the on-load tap-changer!

- Do not perform more than 120 tap-change operations on the on-load tap-changer.
- Before operating for the first time after drying, the on-load tap-changer must be filled with oil up to the corresponding mark.
**NOTICE**

**Damage to motor-drive unit!**

Too many tap-change operations in succession will damage the motor!

- Perform no more than 120 tap-change operations in succession to avoid damaging the motor.

### 7.3.1 Carrying out the transformer ratio test

We recommend carrying out a transformer ratio test before the transformer is dried.

1. **NOTICE!** Carry out the transformer ratio test in all operating positions. Never overshoot the end positions, which are indicated in the connection diagram supplied with the delivery.

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

### 7.3.2 Measuring DC resistance on transformer

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

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

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

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

Table 7: Maximum permitted measured currents when measuring DC resistance on transformer
8 Drying the on-load tap-changer

**NOTICE**

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

Rapid changes in pressure during the drying process and the oil fill can damage the on-load tap-changer accessories!

- Remove on-load tap-changer accessories, such as dehydrating breather and pressure relief devices, before drying and filling with oil.

A prerequisite for the dielectric values assured by MR for the on-load tap-changer is a minimum drying procedure performed following the instructions below and that the on-load tap-changer is treated as part of the transformer during the drying process.

1. Remove on-load tap-changer accessories, such as dehydrating breather and pressure relief devices, before drying and seal the connection points.

2. Connect on-load tap-changer and transformer gas spaces through the vent plug.
   - There is no difference in pressure between the on-load tap-changer oil compartment and transformer tank during the drying process, not even at the terminal board and sealing system.

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

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

5. Vacuum dry on-load tap-changer at between 105 °C and maximum 110 °C. Residual pressure of no more than \(10^{-3}\) bar \([0.75 \text{ Torr/0.015 psi}]\).
   - The drying period depends on the drying period of the transformer but should be at least 50 hours.

6. Always break the vacuum with dry, inert gas to prevent moisture contamination.

The on-load tap-changer is designed for a full vacuum without any limitation on use. The terminal board is designed to withstand a maximum differential pressure of 1241 mbar \([931 \text{ Torr/18 psi}]\). This allows for a full vacuum in the on-load tap-changer’s oil compartment with a maximum positive pressure of 227 mbar \([171 \text{ Torr/3.3 psi}]\) on the transformer side of the terminal board.
9 Filling on-load tap-changer with oil

Before applying operating voltage, the on-load tap-changer oil compartment must be filled with oil to the corresponding mark under a vacuum. To do so, proceed as follows:

1. Make the oil input and vacuum connections to the oil compartment. Remove ¼” coupling and connect to the dehydrating breather.

2. 2 hours before and during filling, maintain a vacuum of less than 1.33 mbar [1 Torr/0.02 psi] on the on-load tap-changer oil compartment.
   ⇒ Degassed oil will facilitate this process.

3. Break the vacuum with dry, inert gas.

4. Take 3 oil samples from the oil compartment of the on-load tap-changer. Determine dielectric strength and water content at oil temperature of 20 °C ± 5 °C.
   ⇒ The dielectric strength and water content must comply with the limit values provided in the appendix [► 71].

5. Use motor-drive unit to switch on-load tap-changer across entire range from 16 L to 16 R and then leave de-energized for an hour.
   ⇒ The gas bubbles break up in the oil.

6. Close on-load tap-changer oil compartment openings.
10 Fitting accessories

10.1 Fitting dehydrating breather

Figure 14: Mounting dehydrating breather
To mount the dehydrating breather, proceed as follows:

1. Fill chamber of dehydrating breather with dry drying agent through flange opening on top (approx. 2.2 lb (1 kg)).

2. Place flange gasket on flange and position retaining plate. The tapped hole and flange opening must be in line. Secure with two M10 x 35 hex bolts, washers and locking nuts.

3. Fit dehydrating breather chamber on mounting pad (provided by customer) on wall of transformer tank. See sketch A (see above) for recommended mounting pad dimensions. Secure with two M10 x 35 hex bolts, washers and locking nuts.

4. Connect tubing between top of dehydrating breather and one of the 0.25" half couplings on the on-load tap-changer side walls.

All connections must be air tight. Use of a high temperature grease on the screw joints helps prevent rust and permits the parts to be removed easily when necessary.
5. Remove the clear plastic oil compartment by squeezing the retaining brackets. Fill it with clean transformer oil until the oil level is between the two fill level lines on the compartment. Carefully place the filled oil compartment back onto the dehydrating breather housing bottom.

![Dehydrating breather diagram](image)

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3/8&quot; union nut</td>
</tr>
<tr>
<td>2</td>
<td>Retaining plate</td>
</tr>
<tr>
<td>3</td>
<td>Mounting block (secured to transformer wall)</td>
</tr>
<tr>
<td>4</td>
<td>Protective grate</td>
</tr>
<tr>
<td>5</td>
<td>Oil collection container</td>
</tr>
<tr>
<td>6</td>
<td>Fill-level mark</td>
</tr>
</tbody>
</table>

**10.2 Pressure relief device MPreC®**

For detailed information about the pressure relief device, please refer to the relevant operating instructions.

Ensure that the relevant circuit breaker immediately de-energizes the transformer as soon as the pressure relief device or any other protective device triggers. To do this, loop one signaling contact into the tripping circuit of the circuit breaker for each protective device.
11 Commissioning at the transformer manufacturer's site

**WARNING**

Danger of death or severe injury!
Danger of death or severe injury from explosive gases in the on-load tap-changer, in the pipework system, at the dehydrating breather opening and from flying parts and hot oil splashing!

► Make sure that only trained technicians perform work on the transformer.
► Use suitable personal protective equipment/clothing.
► Ensure that there are no naked flames, hot surfaces or sparks (for example caused by static charging) in the immediate surroundings and that none occur.
► Only use conductive and grounded hoses, pipes, and pump equipment that are approved for flammable liquids.
► Ensure that the oil compartment of the on-load tap-changer is correctly filled with oil as per the instructions.
► Ensure that all the on-load tap-changer's safety equipment is ready for use.
► Keep away from the danger area during the transformer test.
► Observe applicable fire protection regulations.

**WARNING**

Danger of death and damage to property!
Danger of death and damage to property due to incorrect operation during commissioning!

► Only start up transformer if the functions described in the Checks after assembly [► 38] chapter are satisfied.
► Only actuate on-load tap-changer with the hand crank if the transformer is de-energized and the motor protective switch switched off.

☞ Otherwise damage to the transformer and/or personal injury may result if any of the vacuum interrupters fails to interrupt.
► During operation, if the monitoring system trips, do not reset until the on-load tap-changer has been inspected and the cause of the problem corrected.
► Contact Reinhausen Manufacturing for assistance if needed.

11.1 Checks before commissioning

Before the transformer is switched on for the first time, perform the checks detailed in Chapter Checks after assembly [► 38]. Be sure to carry out the checks for the motor-drive unit and monitoring system, which are described in the operating instructions for the motor-drive unit.
11 Commissioning at the transformer manufacturer's site

11.2 Performing trial tap-change operations

Before energizing the transformer, test tap change operations must be carried out to check the mechanical functions of on-load tap-changer and motor-drive unit after drying and filling with oil. Follow the description provided in the operating instructions for the motor-drive unit.

1. Ensure that the on-load tap-changer attains the desired operating position after switching over.
2. Undertake tap change operation tests across entire range of settings.
3. Check, in both end positions, the function of the electrical and mechanical end stop.

11.3 High-voltage tests on the transformer

**WARNING**

Danger of death or severe injury from explosive gases in the on-load tap-changer, in the pipework system, at the dehydrating breather opening and from flying parts and hot oil splashing!

► Make sure that only trained technicians perform work on the transformer.
► Use suitable personal protective equipment/clothing.
► Ensure that there are no naked flames, hot surfaces or sparks (for example caused by static charging) in the immediate surroundings and that none occur.
► Only use conductive and grounded hoses, pipes, and pump equipment that are approved for flammable liquids.
► Ensure that the oil compartment of the on-load tap-changer is correctly filled with oil as per the instructions.
► Ensure that all the on-load tap-changer's safety equipment is ready for use.
► Keep away from the danger area during the transformer test.
► Observe applicable fire protection regulations.

Perform the high voltage tests on the transformer to check joint operation of the transformer and on-load tap-changer and to rule out irregularities or malfunctions.

It is essential that you ensure only trained, instructed expert personnel who are familiar with and comply with the pertinent safety and technical regulations, who are aware of the potential risks, and who consistently use the occupational safety equipment provided to prevent injury and property damage are assigned to perform such a transformer test.

Note the following points before undertaking high voltage tests on the transformer:

- Ensure that the ground connections on the motor-drive protective housing and protective housing fastening are free of paint.
11 Commissioning at the transformer manufacturer's site

- Only perform high voltage test if motor-drive unit door is closed.
- Disconnect external connections to electronic components in the motor-drive unit to prevent damage from overvoltage.
- When connecting the motor-drive unit's supply voltage, only use the holes in the protective housing base intended for lead insertion.
- Guide all ground connecting leads to one central connection point (establishment of suitable reference earth).
- Disconnect all electronic components before the high voltage test. Before a wiring dielectric test, remove all devices with a withstand voltage of < 1,000 V.
- Leads used for testing must be removed before the high voltage test, as these function as antennas.
- Wherever possible, route the measurement and data leads separately from the energy cables.

Contact the manufacturer if you have any questions about possible sources of danger.
12 Transporting transformer to installation site

**12.1 Transport with removed drive**

Proceed as follows to transport the transformer with removed drive:

1. Before disassembly, ensure that the tap position indicator on the motor-drive unit is in Neutral.

2. **NOTICE!** If the on-load tap-changer and motor-drive unit are not connected, mechanical damage will result from both the drive shaft of the on-load tap-changer turning and the output shaft of the motor-drive unit turning.

3. Remove motor-drive unit.

4. Do not actuate the motor-drive unit while the on-load tap-changer is not coupled.

5. Do not actuate an on-load tap-changer which is not coupled and secure drive shaft to prevent twisting. Use the cotter pin provided.

6. Transport the drive to the installation site in the delivery packaging.

7. Fit drive and drive shaft at operating site as described in operating instructions.
13 Commissioning the transformer at the operating site

**WARNING**
Danger of death or severe injury!
Danger of death or severe injury from explosive gases in the on-load tap-changer, in the pipework system, at the dehydrating breather opening and from flying parts and hot oil splashing!

- Make sure that only trained technicians perform work on the transformer.
- Use suitable personal protective equipment/clothing.
- Ensure that there are no naked flames, hot surfaces or sparks (for example caused by static charging) in the immediate surroundings and that none occur.
- Only use conductive and grounded hoses, pipes, and pump equipment that are approved for flammable liquids.
- Ensure that the oil compartment of the on-load tap-changer is correctly filled with oil as per the instructions.
- Ensure that all the on-load tap-changer's safety equipment is ready for use.
- Keep away from the danger area during the transformer test.
- Observe applicable fire protection regulations.

**WARNING**
Danger of death and damage to property!
Danger of death and damage to property due to incorrect operation during commissioning!

- Only start up transformer if the functions described in the Checks after assembly [38] chapter are satisfied.
- Only actuate on-load tap-changer with the hand crank if the transformer is de-energized and the motor protective switch switched off.
  - Otherwise damage to the transformer and/or personal injury may result if any of the vacuum interrupters fails to interrupt.
- During operation, if the monitoring system trips, do not reset until the on-load tap-changer has been inspected and the cause of the problem corrected.
- Contact Reinhausen Manufacturing for assistance if needed.

**NOTICE**
Damage to motor-drive unit!
Too many tap-change operations in succession will damage the motor!

- Perform no more than 120 tap-change operations in succession to avoid damaging the motor.
13 Commissioning the transformer at the operating site

13.1 Performing trial tap-change operations

Before energizing the transformer, test tap change operations must be carried out to check the mechanical functions of on-load tap-changer and motor-drive unit after drying and filling with oil. Follow the description provided in the operating instructions for the motor-drive unit.

1. Ensure that the on-load tap-changer attains the desired operating position after switching over.
2. Undertake tap change operation tests across entire range of settings.
3. Check, in both end positions, the function of the electrical and mechanical end stop.

13.2 Safety current circuits

**WARNING**

**Danger of death or severe injury!**

An energized transformer and energized on-load tap-changer components could cause death or serious injuries during connection work!

► Connections and associated checks may only be undertaken by trained electricians.
► The relevant safety instructions must be observed.
► Ensure connections in accordance with connection diagrams provided.

Check that the safety current circuits of the transformer, transformer circuit breaker, on-load tap-changer, motor-drive unit and all associated safety equipment are complete and fully functional. This includes e.g.:

1. Correct signalling of the monitoring system to monitor the on-load tap-changer's vacuum interrupters in the transformer's control cabinet.
2. For locking and control purposes, do not use the position transmitter equipment. 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.
3. Ensure that the pressure relief device's signaling contact is correctly looped into the tripping circuit of the transformer circuit breaker.
4. Loop the signaling contact for falling below the minimum oil level in the on-load tap-changer oil compartment into the tripping circuit of the circuit breaker.
5. **NOTICE!** When these protective devices are tripped, the transformer must be immediately de-energized by the circuit breaker.
6. **DANGER!** Systems which only generate an alarm message are not permitted.
13 Commissioning the transformer at the operating site

13.3 Switching on transformer

**WARNING**
Danger of death or severe injury due to the on-load tap-changer overloading!

The inrush current impulses of the transformer are usually a multiple of the transformer rated current and can overload the on-load tap-changer during the diverter switch operation.

- Once the transformer has been switched on, ensure that the inrush current impulse has fully subsided before undertaking an on-load tap change operation.

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

Damage to the on-load tap-changer due to excessive oil temperature!

- Operate on-load tap-changer the temperature range of the surrounding transformer oil of between -25 °C and +100 °C. Do not exceed temperature limit values.

Once all the preparations described above are complete and once the function of all protective devices has been ensured, you can energize the transformer.

After the transformer has been switched on and the inrush current impulse has subsided, on-load tap-changer tap-change operations can be performed both under no load and load conditions.
14 Actuating motor-drive unit with hand crank

**WARNING**

Danger of death and severe injury!
An energized transformer and energized on-load tap-changer components could cause death or serious injuries during hand crank operation!

► Switch off and lock transformer to prevent unintentional restart.
► Make sure 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.
► Only actuate the motor-drive unit with the hand crank fitted in the motor-drive unit. Otherwise, there is a risk of serious injury.

☞ The hand crank interlock switch disconnects the motor circuit at two poles. (However, it does not disconnect the control circuit.)
► Only actuate motor-drive unit with hand crank in an emergency. An emergency should be understood to be failure of the motor-drive unit's voltage supply when there is an urgent need to perform a tap change.
► It is essential to complete all started tap changes without changing direction of rotation. The tap change is complete when the pointer is in the mid-position of the area marked in gray on the tap-change indicator.

Proceed as follows to operate the on-load tap-changer with the hand crank:

1. Open doors of motor-drive unit
2. Switch off motor protective switch 8-2
3. Take hand crank out of bracket and place on drive shaft on motor-drive unit
4. Carry out tap-change operation (7.5 hand crank revolutions)
   ☞ The pointer of the tap-change indicator must be in mid-position within the gray field once the on-load tap-changing operation is complete.
5. Take off hand crank and return to bracket
6. Switch on motor protective switch 8-2
7. Close motor-drive unit doors
15 Monitoring during operation

**WARNING**

Danger of death or severe injury!

Danger of death or severe injury from explosive gases in the on-load tap-changer, in the pipework system, at the dehydrating breather opening and from flying parts and hot oil splashing!

- Make sure that only trained technicians perform work on the on-load tap-changer and motor-drive unit.
- Use suitable personal protective equipment/clothing.
- Ensure that there are no naked flames, hot surfaces or sparks (for example caused by static charging) in the immediate surroundings and that none occur.
- Ensure that the oil compartment of the on-load tap-changer is correctly filled with oil as per the instructions.
- Ensure that all the on-load tap-changer’s safety equipment is ready for use.
- Never actuate on-load tap-changer with the hand crank if the transformer is energized.

Monitoring the on-load tap-changer and motor-drive unit during operation differs for annual checks and occasional visual checks.

If faults occur during operation, please refer to the Fault elimination [► 56] chapter for a remedy.

### 15.1 Annual checks

**Every year check:**

1. Oil quality
2. Motor-drive unit
3. Return to starting position in the event of error

### 15.1.1 Checking oil quality

Once a year check the dielectric strength and water content of the mineral insulating oil in the on-load tap-changer. Proceed as follows:

1. Take 3 oil samples from the on-load tap-changer oil compartment.
2. Record temperature of oil sample just after sample is taken.
3. Determine dielectric strength and water content at an on-load tap-changer oil temperature of 20 °C ± 5 °C. The dielectric strength and water content must comply with the limit values provided in the appendix [► 71].
4. Treat or replace mineral insulating oil if the oil samples do not meet the limit values specified. Use mineral insulating oil for transformers in accordance with IEC 60296.
15 Monitoring during operation

15.1.2 Checking motor-drive unit

A detailed description of how to check the switching functions and mechanical end stop can be found in the operating instructions for the motor-drive unit.

15.1.3 Checking return to starting position

Check whether the on-load tap-changer goes back to its starting position in the event of an error. Proceed as follows:

1. Use RAISE/LOWER rotary button to perform tap-change operation in any direction and then press the monitoring system’s green TEST push-button during the tap-change operation.
   ⇒ An alarm signal is generated, the motor-drive unit stops and returns to its starting position.

2. Press the monitoring system’s red RESET push-button to reset the alarm status.

3. Perform tap-change operation in opposite direction and then again press the green TEST push-button during the tap change.
   ⇒ An alarm signal is generated, the motor-drive unit stops and returns to its starting position.

4. Press the red RESET push-button to reset the alarm status.

15.2 Occasional visual checks

As well as the annual checks, perform occasional visual checks. You can combine these visual checks with the usual checks on the transformer.

These visual checks may only be undertaken by trained experts.

Pay particular attention to the following:

- Oil impermeability on sealing points of on-load tap-changer and connected protective devices
- Gaskets of the protective housing of the motor-drive unit
- Correct functioning of the electrical heater and installed accessories in the protective housing of the motor-drive unit
- Correct function of protective devices (see also associated operating instructions)
- Change in color of drying agent in dehydrating breather
16 Fault elimination

16.1 General information

**WARNING**

Danger of death or severe injury!

Danger of death or severe injury from explosive gases in the on-load tap-changer, in the pipework system, at the dehydrating breather opening and from flying parts and hot oil splashing!

► Make sure that only trained technicians perform work on the on-load tap-changer and motor-drive unit.

► Use suitable personal protective equipment/clothing.

► Ensure that there are no naked flames, hot surfaces or sparks (for example caused by static charging) in the immediate surroundings and that none occur.

► Ensure that the oil compartment of the on-load tap-changer is correctly filled with oil as per the instructions.

► Ensure that all the on-load tap-changer's safety equipment is ready for use.

► Never actuate on-load tap-changer with the hand crank if the transformer is energized.

**WARNING**

Danger of death due to electrical voltage and danger of damage to on-load tap-changer due to improper resetting after a fault!

During operation, if the monitoring system trips, do not reset until the on-load tap-changer has been inspected and the cause of the problem corrected.

► Only operate on-load tap-changer with the transformer energized if the monitoring system is properly connected and functional.

► If necessary, consult with Reinhausen Manufacturing.

**NOTICE**

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

Activation of a protective device may indicate damage! Switching on without checking may result in damage to the on-load tap-changer and transformer!

► Check on-load tap-changer, motor-drive unit and transformer when a protective device has been tripped.

► Do not use the equipment again until you are sure there is no damage to the on-load tap-changer or transformer.

16.2 Fault elimination overview

The table below is intended to assist with detecting and, where possible, remedying faults. Contact Reinhausen Manufacturing for assistance if needed.
<table>
<thead>
<tr>
<th>Error pattern</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Tripping of pressure relief device or other protective devices (for example MPreC®)</td>
<td>▪ Have on-load tap-changer and transformer checked by trained personnel</td>
</tr>
<tr>
<td>▪ Error signaled on monitoring system by red or yellow LEDs</td>
<td>▪ Have on-load tap-changer and monitoring system checked by trained personnel</td>
</tr>
<tr>
<td>▪ Tripping of motor protective switch in motor-drive unit</td>
<td>▪ Have motor-drive unit and on-load tap-changer checked by trained personnel</td>
</tr>
<tr>
<td>▪ Tripping of signaling contact that indicates that the oil has fallen below the minimum oil level</td>
<td>▪ Have on-load tap-changer checked for leaks by trained personnel</td>
</tr>
<tr>
<td>▪ On-load tap-changer not changing tap position (slug-gishness, RAISE/LOWER pivot switch not working)</td>
<td>▪ Contact Reinhausen Manufacturing</td>
</tr>
<tr>
<td>▪ No change in voltage on transformer despite change in position on motor-drive unit</td>
<td>▪ Contact Reinhausen Manufacturing</td>
</tr>
<tr>
<td>▪ Noises on drive shaft or motor-drive unit when changing tap position</td>
<td>▪ Check that drive shaft is fitted correctly</td>
</tr>
<tr>
<td>▪ Deviation from desired value during dissolved gas analysis</td>
<td>▪ Contact Reinhausen Manufacturing and provide measured values</td>
</tr>
<tr>
<td>▪ Deviation from limit values for on-load tap-changer oil (dielectric strength and water content)</td>
<td>▪ Perform oil change</td>
</tr>
<tr>
<td>▪ Warning or tripping of Buchholz relay on transformer</td>
<td>▪ Notify manufacturer of transformer</td>
</tr>
<tr>
<td></td>
<td>▪ Check oil quality</td>
</tr>
<tr>
<td></td>
<td>▪ Check that hose clips and protective covers are seated correctly</td>
</tr>
<tr>
<td></td>
<td>▪ Ensure that all components are fastened correctly within motor-drive unit</td>
</tr>
<tr>
<td></td>
<td>▪ Contact Reinhausen Manufacturing and provide measured values</td>
</tr>
</tbody>
</table>
### Error pattern

<table>
<thead>
<tr>
<th>Error pattern</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviation from desired value when measuring winding resistance of transformer</td>
<td>Contact manufacturer of transformer and, if necessary, Reinhausen Manufacturing and provide measured values</td>
</tr>
<tr>
<td>Deviation from desired value during transformer ratio test</td>
<td>Contact manufacturer of transformer and, if necessary, Reinhausen Manufacturing and provide measured values</td>
</tr>
</tbody>
</table>

Table 8: Fault elimination

In the event of faults on the on-load tap-changer and motor-drive unit, which cannot be easily and immediately corrected on site, or if a protective device has been tripped, please inform your authorized Reinhausen Manufacturing representative, the transformer manufacturer or contact us directly at:

Reinhausen Manufacturing Inc.
2549 North 9th Avenue, 38343 Humboldt, Tennessee, USA
Tel.: +1 731 784 7681
Fax: +1 731 784 7682

### 16.3 Monitoring system displays and controls

![Monitoring system displays and controls](image)

The following displays and controls of the monitoring system (Vacuum Interrupter Monitoring VIM) are located behind the motor-drive unit's door:

- The green TEST push-button is used to check the internal circuitry of the monitoring system.
- 1 green LED indicates the control voltage supply present
16 Fault elimination

- 3 red LEDs (1 per phase) indicate when a vacuum interrupter malfunction has been recorded
  - The monitoring system performs this check during every diverter switch operation
- 3 yellow LEDs (1 per phase) indicate the loss of the current transformer signal
  - The monitoring system repeats this check after every 32 tap-change operations
- The red RESET push-button has to be pressed to reactivate the monitoring system after a check

### 16.4 Overview of monitoring system operating statuses

In the motor-drive unit, LEDs on the monitoring circuit board and on the swing frame indicate various operating states or events:

<table>
<thead>
<tr>
<th>Operating status</th>
<th>Monitoring display</th>
<th>Swing frame display</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Green LED Power</td>
<td>Yellow LED Fault</td>
</tr>
<tr>
<td>Normal operation</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>Control voltage supply fault</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Loss of current transformer signal</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>Vacuum interrupter error</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>Maintenance mode</td>
<td>ON</td>
<td>FLASHING</td>
</tr>
<tr>
<td>Test mode</td>
<td>ON</td>
<td>OFF</td>
</tr>
</tbody>
</table>
17 Maintenance

In addition to the annual checks and occasional visual checks, also perform maintenance work whenever a maintenance interval is reached.

Maintenance work on the on-load tap-changer and motor-drive unit may only be undertaken by trained experts. If this route is taken, in addition to the correct performance of all work, certain components will be upgraded to the latest state of technology and manufacturing status.

Contact the Technical Service team at Reinhausen Manufacturing to perform maintenance work:

Reinhausen Manufacturing Inc.
2549 North 9th Avenue, 38343 Humboldt, Tennessee, USA
Tel.: +1 731 784 7681
Fax: +1 731 784 7682

If maintenance is not carried out by our Technical Service department, please ensure that the personnel who carry out the maintenance are trained by MR or are otherwise suitably qualified to carry out the work.

In such cases, we would ask you to forward to us a report on the maintenance performed so we can update our maintenance files. For inquiries about spare parts, please provide the serial number (see name plate on on-load tap-changer and motor-drive unit) and the number of tap-change operations.

17.1 Maintenance intervals

**NOTICE**

Damage to on-load tap-changer and transformer!

Damage to on-load tap-changer and transformer from non-observance of maintenance intervals and improper maintenance!

► Observe maintenance intervals.
► Ensure complete and proper maintenance.

Perform maintenance after every 500,000 operations.
17.2 Taking on-load tap-changer out of service

1. Switch off and lock transformer to prevent unintentional restart.
2. Make sure everything is de-energized.
3. Visibly connect all transformer terminals to ground (grounding leads, grounding disconnectors) and short circuit them.
4. Cover or cordon off adjacent energized parts.
5. Open motor-drive unit and switch off motor protective switch 8-2.
6. Record the number of operations shown on the on-load tap-changer's operations counter.

17.3 Draining oil and testing oil quality

**WARNING**

Danger of death or severe injury!

Danger of death or severe injury from explosive gases in the on-load tap-changer, in the pipework system, at the dehydrating breather opening and from flying parts and hot oil splashing!

► Ensure that there are no naked flames, hot surfaces or sparks (for example caused by static charging) in the immediate surroundings and that none occur.
► Only use conductive and grounded hoses, pipes and pump equipment that are approved for flammable liquids.
► Rinse the gas space with dry nitrogen before filtering
► Ground the transformer, its bushings and all equipment for handling oil.
► Use suitable personal protective equipment/clothing.
► Keep away from the danger area during the transformer test.
► Observe applicable fire protection regulations.
► Make sure that only trained technicians perform work on the transformer.

1. Take oil sample from on-load tap-changer.
2. Check and record dielectric strength and water content of insulating oil.
3. Remove the vent plug on top of the on-load tap-changer oil compartment and drain oil.
4. If the oil is to be reused and if it is still within the limit values [► 71]: Pump through a filter press and then store in clean, dry containers.
5. Open door to on-load tap-changer oil compartment. Check the door gasket for signs of deterioration and use new gasket if required.

17.4 Investigating vacuum interrupters

17.4.1 External integrity check

1. Check whether any external damage is visible.
2. Check the condition of the flexible connector for broken strands.
   ⇨ If damage is visible, contact Reinhausen Manufacturing.

17.4.2 Checking contact erosion indicator

The vacuum interrupter is rated for one million operations at full load.

The contact erosion indicator can be found behind a viewing window in the cover plate of the drive mechanism for the vacuum interrupters. It comprises a stationary indicator and moving scale.

![Figure 17: Vacuum interrupter contact erosion indicator](image1)

![Figure 18: Contact erosion indicator viewing window](image2)

A scale showing the start (S) and the finish (F) points is engraved. This scale is a visual indication which gives a rough estimate of contact wear.

1. With a new on-load tap-changer or after the vacuum interrupters have been replaced, the indicator must be at the S (start) mark.

2. When the on-load tap-changer is opened for the first time and during subsequent checks: check the indicator so that contact wear can be evaluated.

   ⇨ By observing the position of the pointer on the scale and the number of actual tap-change operations, a rough estimate of the remaining life can be made.
If the contact erosion indicator is close to the F (finish) mark, contact Reinhausen Manufacturing to have the vacuum interrupters replaced.

17.4.3 Replacing vacuum interrupter

The vacuum interrupters have reached the end of their lives once excessive contact wear is detected or after 1 million on-load tap-change operations. Contact Reinhausen Manufacturing to replace the vacuum interrupters. This may only be done by people who have attended a special training course.

17.5 Checking by-pass switch

- Check the condition of the by-pass switch contacts $P_2$ and $P_3$.

  During the tap-change operation, these contacts produce an arc when opening while the current of the on-load tap-changer is commuted to the vacuum interrupters. Arcing tips are therefore provided which separate the $P_2$ or $P_3$ shortly after the moving finger opens. These arcing tips usually last longer than the vacuum interrupters.

Figure 19: By-pass switches $P_2$ and $P_3$
17.6 Maintaining motor-drive unit

After 500,000 tap-change operations, the braking contactor in the motor-drive unit must be replaced. Contact Reinhausen Manufacturing's Technical Service department.

When maintaining the motor-drive unit, ensure the functions as per the Checks after assembly chapter.

17.7 Maintaining monitoring system

When maintaining the on-load tap-changer and motor-drive unit, perform the following checks on the monitoring system:

1. Ensure that the fiber-optic cable is treated with care during maintenance. The bend radius must not fall below 4" (100 mm). Overbending will damage the cable and diminish its ability to carry a light pulse.

2. Ensure monitoring system functions in accordance with the Checks after assembly chapter.
17.8 Maintaining dehydrating breather

If the oil pressure in the dehydrating breather exceeds the difference in pressure between the on-load tap-changer’s gas space and the atmosphere, the breather permits in- and out-breathing. The drying agent is protected from the ambient humidity by the oil in the dehydrating breather which also serves to trap any particles in the air during in-breathing.

The cylindrical body is filled with drying agent which is orange in color when in the dry state. When saturated with moisture, the drying agent changes to a green color or becomes colorless depending on the type used. Two different drying agents are available:

- Silica gel (6 to 16 grain size) which is orange in color when in dry state. It turns green when saturated.
- Sorbead® ORANGE (4 to 8 grain size) which is orange in color when in dry state. It turns colorless when saturated.

The intervals for changing the drying agent depend on the transformer’s load cycle and the ambient conditions.

1. Check the color of the agent frequently at first, to determine the approximate time interval for replacement of the drying agent for the particular application.
2. Observe the color change through the observation ports in the protective grate. Replace drying agent as soon as 75% has changed from orange to green/colorless.
3. To replace the drying agent, carefully remove and empty the oil compartment.
4. Take dehydrating breather out of bracket by loosening the two M10 x 35 hex bolts.
5. Drain the saturated drying agent through the aperture in the top flange and collect in a collecting plate.
6. Fill dehydrating breather with new drying agent.
7. Place dehydrating breather in bracket, ensuring that the flange seal is seated correctly.
8. Fill oil compartment with clean transformer oil up to the marked level.
9. Finally place oil compartment in bracket.
10. Dry the removed saturated drying agent in an uncovered collecting plate at 130 to 160 °C for approx. 2 to 3 hours and store in a dry location until replacing again.

When dry, the agent will again be orange. Since the particles dry from the outside in, the color first starts to change on the outside. This initial change in color does not indicate that the drying agent is fully reactivated.

We recommend keeping a second batch of drying agent in a sealed container. This means that the dehydrating breather can be quickly refilled.
17.9 Preparing the on-load tap-changer for service

Once the maintenance work described above has been performed, proceed as follows:

1. Wipe down walls and insulating surfaces in on-load tap-changer oil compartment, removing contaminated oil, carbon deposits, metallic debris and condensate.

2. Undertake tap change operation tests with motor-drive unit and check the monitoring system, see Checks after assembly [► 38].

3. Check that the fiber-optic cable is laid correctly. The bend radius must not fall below 4" (100 mm). Overbending will damage the cable and diminish its ability to carry a light pulse.

4. Close on-load tap-changer oil compartment. To do so, tighten nuts of door to a maximum tightening torque of 11 lb·ft (15 Nm).

5. Make the oil input connections to the on-load tap-changer drain valve.

6. Remove ¼" coupling and connect to the dehydrating breather.

7. Fill on-load tap-changer oil compartment to the specified mark with clean, dry oil using a filter press. Use mineral insulating oil for transformers in accordance with IEC 60296.

8. After oil filling, close the on-load tap-changer oil compartment openings again and reconnect the dehydrating breather.

9. Use motor-drive unit to perform around 100 tap-changes without an interruption and return to Neutral.

10. Let the on-load tap-changer sit de-energized for one hour to allow gas bubbles in the oil to break up.

11. Take 3 oil samples from the on-load tap-changer oil compartment.

   ☐ Determine dielectric strength and water content at an on-load tap-changer oil temperature of 20 °C ± 5 °C. The dielectric strength and water content must comply with the limit values provided in the appendix.

12. Check on the dehydrating breather whether the drying agent is dry and the oil level in the clear plastic oil collection compartment is between the two fill level lines.

13. Remove the grounding elements (grounding leads, grounding disconnectors) fitted at the start of the maintenance work.
18 Technical data

In addition to the technical data provided here, also note the documents provided with the order confirmation and the information in the Intended use [► 12] section.

The RMV-II on-load tap-changer meets the requirements of IEC 60214-1:2003 and ANSI/IEEE C57.131:2012.

During change-over selector connection, a potential shift occurs at the tapped winding, which results in voltage at the deactivating change-over selector contact. This voltage is known as the recovery voltage.

The maximum permissible recovery voltage at the deactivating change-over selector contact is 20 kV. Tie-in resistors are needed if 20 kV is exceeded.

<table>
<thead>
<tr>
<th>On-load tap-changer type RMV-II</th>
<th>600-15</th>
<th>1000-15</th>
<th>1500-15</th>
<th>2000-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage [kV]</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Nominal power of transformer (3 phase) [kVA]</td>
<td>14,400</td>
<td>24,000</td>
<td>36,000</td>
<td>48,000</td>
</tr>
<tr>
<td>Maximum rated through current of on-load tap-changer [A]</td>
<td>600</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
</tr>
<tr>
<td>Maximum circulating current of preventive auto transformer [A]</td>
<td>300</td>
<td>500</td>
<td>750</td>
<td>700</td>
</tr>
<tr>
<td>Rated short-circuit current (peak) [kA]</td>
<td>15</td>
<td>25</td>
<td>56.25</td>
<td>56.25</td>
</tr>
<tr>
<td>Rated short-time current (2 sec) [kA]</td>
<td>6</td>
<td>10</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td>Voltage between two taps [V]</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) between two phases and to ground [kV]</td>
<td>125</td>
<td>125</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>Power frequency withstand voltage test between two phases and to ground [kV]</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) across all taps [kV]</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Power frequency withstand voltage test across all taps [kV]</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) between two taps [kV]</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Power frequency withstand voltage test between two taps [kV]</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Number of operating positions</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Number of tap winding taps</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 9: Technical data for the VACUTAP® RMV-II (15 kV)
<table>
<thead>
<tr>
<th>Operating voltage [kV]</th>
<th>600-26.4</th>
<th>1000-26.4</th>
<th>1500-26.4</th>
<th>2000-26.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal power of transformer (3 phase) [kVA]</td>
<td>14,400</td>
<td>24,000</td>
<td>36,000</td>
<td>48,000</td>
</tr>
<tr>
<td>Maximum rated through current of on-load tap-changer [A]</td>
<td>600</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
</tr>
<tr>
<td>Maximum circulating current of preventive auto transformer [A]</td>
<td>300</td>
<td>500</td>
<td>750</td>
<td>700</td>
</tr>
<tr>
<td>Rated short-circuit current (peak) [kA]</td>
<td>15</td>
<td>25</td>
<td>56.25</td>
<td>56.25</td>
</tr>
<tr>
<td>Rated short-time current (2 sec) [kA]</td>
<td>6</td>
<td>10</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td>Voltage between two taps [V]</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) between two phases and to ground [kV]</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Power frequency withstand voltage test between two phases and to ground [kV]</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) across all taps [kV]</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Power frequency withstand voltage test across all taps [kV]</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) between two taps [kV]</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Power frequency withstand voltage test between two taps [kV]</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Number of operating positions</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Number of tap winding taps</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 10: Technical data for VACUTAP® RMV-II (26.4 kV)
### On-load tap-changer type RMV-II

<table>
<thead>
<tr>
<th></th>
<th>1500-72,5</th>
<th>2000-72,5</th>
<th>2500-72,5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage [kV]</td>
<td>72.5</td>
<td>72.5</td>
<td>72.5</td>
</tr>
<tr>
<td>Nominal power of transformer (3 phase) [kVA]</td>
<td>72,000</td>
<td>96,000</td>
<td>120,000</td>
</tr>
<tr>
<td>Maximum rated through current of on-load tap-changer [A]</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
</tr>
<tr>
<td>Maximum circulating current of preventive auto transformer [A]</td>
<td>750</td>
<td>700</td>
<td>875</td>
</tr>
<tr>
<td>Rated short-circuit current (peak) [kA]</td>
<td>56.25</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Rated short-time current (2 sec) [kA]</td>
<td>22.5</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) between two phases and to ground [kV]</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Power frequency withstand voltage test between two phases and to ground [kV]</td>
<td>140</td>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) across all taps [kV]</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Power frequency withstand voltage test across all taps [kV]</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Impulse withstand voltage (full wave) between two taps [kV]</td>
<td>125</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>Power frequency withstand voltage test between two taps [kV]</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Number of operating positions</td>
<td>33</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Number of tap winding taps</td>
<td>9 (8 effective)</td>
<td>9 (8 effective)</td>
<td>9 (8 effective)</td>
</tr>
</tbody>
</table>

Table 11: Technical data for VACUTAP® RMV-II (72.5 kV)
## 18.1 General data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>3-phase, preventive auto transformer (reactor) switching concept (to break load current by vacuum interrupters)</td>
</tr>
<tr>
<td>Tank</td>
<td>No limitation on use with full vacuum (± 15 psi)</td>
</tr>
</tbody>
</table>
| Tank dimensions (L x W x H) | 66 x 32 x 50" for 72.5 kV design  
66 x 29 x 43" for 15 and 26.4 kV design                                                                                                          |
| Dimensions of motor-drive unit (L x W x H) | 51.5 x 20 x 23" (maximum 330 lb)                                                                                                             |
| Total weight (including oil) | 5,500 lb for 72.5 kV design  
4,440 lb for 15 and 26.4 kV design                                                                                                           |
| Oil filling quantity       | 345 gals./2,590 lb for 72.5 kV design  
270 gals./2,025 lb for 15 and 26.4 kV design                                                                                                  |
| Time per operation         | Approx. 2 seconds                                                                                                                               |

Table 12: General data

## 18.2 Temperature range

The VACUTAP® RMV-II on-load tap-changer be operated in the rated load range at surrounding oil temperatures of between -25 °C and +100 °C.

On request, a version for Arctic operation is also available, which can be used down to a minimum ambient temperature of -40 °C.
19 Appendix

19.1 Limit values for dielectric strength and water content of on-load tap-changer oil

The following table provides the limit values for dielectric strength (measured in accordance with IEC 60156) and water content (measured in accordance with IEC 60814) of the on-load tap-changer oil for VACUTAP® on-load tap-changers. The values have been established on the basis of IEC 60422.

<table>
<thead>
<tr>
<th></th>
<th>Ud</th>
<th>H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>When commissioning the transformer for the first time</td>
<td>&gt; 60 kV/2.5 mm</td>
<td>&lt; 12 ppm</td>
</tr>
<tr>
<td>During operation</td>
<td>&gt; 30 kV/2.5 mm</td>
<td>&lt; 30 ppm</td>
</tr>
<tr>
<td>After maintenance</td>
<td>&gt; 50 kV/2.5 mm</td>
<td>&lt; 15 ppm</td>
</tr>
</tbody>
</table>

Table 13: Limit values for on-load tap-changer oil
MR worldwide

Australia
Reinhausen Australia Pty. Ltd.
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Fax: +55 11 4785 2185
E-Mail: vendas@reinhausen.com.br

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Fax: +1 450 659 3092
E-Mail: m.foata@ca.reinhausen.com

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Fax: +91 44 26390881
E-Mail: easummr@vsnl.com

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BSD City, Tangerang
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E-Mail: c.haering@id.reinhausen.com

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Fax: +971 4 2368 225
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