

# Operating Instructions

## REOhm Widerstand

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### Important Note

#### READ CAREFULLY BEFORE COMMISSIONING AND KEEP FOR FUTURE REFERENCE

This manual provides all information required for the intended use of the products described. It is intended exclusively for *qualified personnel*.

**Qualified personnel** are individuals who, based on their professional training, experience, and instruction in the field of drive and electrical engineering, as well as their knowledge of applicable standards, regulations, accident-prevention rules, and operating procedures, have been authorized by the operator to perform the required tasks. Such personnel must be able to identify potential hazards and implement appropriate protective measures.

The definition of *qualified personnel* is provided, among others, in **DIN EN 50110-1 (VDE 0105-1)** and **IEC 60364**. These standards also stipulate that *unqualified personnel* must not be permitted to work with this unit.

In addition, knowledge of first aid and local emergency and rescue services is required.

Ensure that all fundamental planning work on the machine or system, as well as all activities related to transport, assembly, installation, commissioning, maintenance, and repair, are performed by qualified personnel or supervised by appropriately responsible specialists.

In particular, observe the following:

#### Safety Instructions for Assembly and Commissioning

For all activities related to **assembly, installation, commissioning, maintenance, and repair**, the following instructions are **mandatory**:

- Comply with the technical data and permissible operating ranges as specified in catalogs, order documents, nameplates, and product labels.
- Observe general installation and safety regulations, in particular the applicable standards (e.g., VDE regulations, DIN standards) and legal requirements.
- Consider local and system-specific requirements, especially regarding electrical protective measures, ambient conditions, and access regulations.
- Use suitable tools and lifting/transport equipment properly to prevent damage and hazards.
- Use personal protective equipment (PPE) in accordance with applicable occupational safety regulations.
- Comply with the specified installation conditions, in particular:
  - Ensure adequate protection against contact during operation.
  - Prevent hazardous approach by means of suitable protective measures (e.g., covers, barriers).

## General Safety Instructions

The following instructions are intended to protect operating personnel and ensure the safety of the products described and all connected equipment.

Compliance with these safety instructions is essential to prevent personal injury and property damage and to ensure safe, standards-compliant operation.



**DANGER!** — Risk of death, highest level of hazard.



**WARNING!** — Medium hazard, risk of serious injury or damage.



**CAUTION!** — Lower hazard, minor injury, property damage, or malfunctions.



**ATTENTION!** — Hot surface.

### WARNING — Electrical energy

Improper handling of electrical energy can result in property damage, serious personal injury, or fatal accidents.

	<b>DANGER!</b>
	<b>Hazardous voltage. Risk of fatal electric shock!</b>
<b>Safety measures:</b>	
<ul style="list-style-type: none"><li>➤ Disconnect the supply voltage on all poles before performing assembly, disassembly, fuse replacement, or modification work.</li><li>➤ Switch off the compressed-air supply before working on pneumatic components.</li><li>➤ Observe accident-prevention and safety regulations, in particular the legal and company requirements in force at the place of use.</li><li>➤ Before commissioning, verify that the device rated voltage matches the local mains voltage.</li></ul>	

 **DANGER!**

**Electric shock due to missing protective earth (Class I)**



For Class I equipment, a missing or faulty protective conductor (PE) can lead to hazardous touch voltage on accessible conductive parts — particularly the enclosure. Contact with these parts can cause severe or fatal electric shock.

**Safety measures:**

- Ensure the equipment is properly grounded (protective earth, PE).
- After installation, verify all protective earth connections for continuity and secure fastening.

 **DANGER!**

**Electric shock from damaged equipment**



Damaged electrical equipment can lead to hazardous touch voltage on enclosure parts or exposed live parts. Contact with these parts can cause severe injury or fatal electric shock.

**Safety measures:**

- Observe the limits for transport, storage, and operation as specified in the technical data.
- Do not use damaged equipment.

 **DANGER!**

**Electric shock due to unbonded cable shields**



Unbonded cable shields can, due to capacitive coupling, generate hazardous touch voltages. Contact with conductive parts of the equipment can cause severe injury or fatal electric shock.

**Safety measures:**

- Bond cable shields and unused conductors of power cables to a grounded chassis potential at least at one end.
- Properly cover all electrical connections to prevent inadvertent contact.

 **DANGER!**

**Electric shock due to insulation failure**

With insufficient cooling, the device's electrical insulation and degree of protection (IP) may fail. This can create hazardous touch voltages, leading to electric shock and damage to adjacent systems.

**Safety measures:**

- Activate forced cooling before power-on and maintain it for at least 1 h after power-off.

**WARNING — Overheating due to incorrect cooling control**

- If forced cooling is switched on too late or deactivated too early, thermal overload and permanent device damage may occur.

**Safety measure:**

- Forced cooling must accompany the entire operating cycle.

**NOTE — Airflow for natural convection**

- Unobstructed air exchange must be ensured so that natural convection can function.

**Safety measure:**

- Observe minimum clearances and installation guidelines as specified in Chapter 5.

**NOTE — Residual heat**

- Even after the resistor is switched off, it continues to transfer heat to the enclosure.

**Safety measure:**

- Deactivate forced cooling only after complete dissipation of residual heat.



 **GEFAHR!**

**Electric shock from damaged components**

Resistors with visible deformation, cracks, or mechanical damage must not be installed, operated, or energized. There is an immediate risk to life due to damaged insulation or contacts.

**Safety measures:**

- Before installation, perform a complete visual inspection by qualified personnel. If damage is found: do not use, remove from service, and contact REO.

**WARNING — Damage due to mechanical impact**

- Improper handling such as shocks, impacts, or bending can destroy the device's function, degree of protection (IP), and electrical insulation.

**Safety measures:**

- Transport resistors without shock, handle according to mounting requirements, and avoid mechanical loads. Avoid pressure, impact, and crushing.



 **DANGER!**

**Risk of fatal electric shock due to unsuitable environmental conditions**

REO resistors have a defined degree of protection (IP) in accordance with DIN EN 60529 (IEC 60529). Storage, transport, installation, or operation in environments exceeding this rating (e.g., humid, contaminated/dust-laden, corrosive) can lead to electrical hazards and irreparable damage. This is particularly critical with open or unprotected cable ends.

**Safety measures:**

- Use the device only in environments that match the IP rating stated on the label.
- Protect open cable ends from moisture and contamination (e.g., with IP-rated cable glands/feedthroughs or enclosure seals).



 **DANGER!**

**Electric shock due to unauthorized tampering**

Unit-mounted elements (e.g., screws, cable glands, rivets, clamping/terminal connections, piping) must not be modified or opened by the user under any circumstances. Such actions can impair the device's electrical insulation and degree of protection (IP) and, in the worst case, lead to electric shock or device failure.

**Safety measure:**

- Perform modifications or interventions only by authorized specialist personnel and only after approval by the manufacturer. Maintain the original condition, especially for safety-related connections.



 **DANGER!**

**Electric shock due to incorrect connection sequence**

Electrical connection must be performed only when de-energized. Before starting work, earth the unit. During wiring, connect the protective conductor (PE) first; live conductors must be connected last.

**Safety measure:**

- Use electrically trained personnel only and ensure the five safety rules according to DIN EN 50110-1 (VDE 0105-1) are applied. Protective earth first, live conductors last.



 **DANGER!**

**Electric shock due to residual energy**

After the REO resistor is switched off, hazardous voltages may still be present at components or terminals.

**Safety measures:**

- Verify absence of voltage by measurement before any contact or work; use suitable, tested measuring equipment only.
- Allow work only by electrically trained/qualified personnel in accordance with DIN EN 50110-1 (VDE 0105-1).



 **DANGER!**

**Fire/explosion hazard due to hot enclosure surfaces**

REO resistors can reach operating temperatures of > 250 °C (482 °F). When operated in environments with combustible media (e.g., gas, dust, aerosols), there is an acute risk of fire and explosion. This is particularly critical with open or unprotected cable ends.

**Safety measure:**

- Install only in a non-combustible environment; periodically check the ambient air for explosive atmospheres.

**WARNING - Burn hazard on contact with the enclosure**

- Hot surfaces can cause severe burns.

**Measure:**

- Affix visible warning labels; touch only when cooled; maintain clearance if required.

**NOTE - Heat propagation to adjacent components**

- Heat from the resistor can transfer to the surroundings and cause damage (e.g., deformation, premature wear).

**Measure:**

- Use heat-resistant materials in the mounting environment; ensure heat dissipation.

**NOTE - Operator responsibility**

- The effects of heat on the mounting system and adjacent parts are the operator's responsibility.

**Measure:**

- Check and document the thermal suitability of the overall system in advance.



 **DANGER!**

**Electric shock due to storage in unsuitable environments**

Storage with condensation and in environments with conductive dust/contamination can cause a loss of insulation integrity. This increases the risk of electric shock, especially during subsequent commissioning.

**Safety measures:**

- Store only in dry, clean indoor areas.
- Use packaging and protective covers during storage.
- Measure insulation resistance before commissioning.

**Note:** See Chapter 4 — Transport and Storage.



 **DANGER!**

**Life-threatening arc hazard when disconnecting a connector during operation**

Disconnecting a connector while energized can cause arc formation. Contact can result in severe burns or fatal electric shock.

**Safety measure:**

- Disconnect connectors only when de-energized.



 **DANGER!**

**Electric shock with enclosure open**

Inside the enclosure, hazardous residual voltages may remain after disconnection from the mains. Contact with live parts can cause severe injury or fatal electric shock.

**Safety measures:**

- Disconnect the device from the mains before opening.
- Verify absence of voltage by measurement and ensure no residual voltage is present (use suitable, tested measuring equipment).





**WARNING!**

**Risk of injury due to improper transport**

Do not lift or mount the device at unsuitable points. Use only designated lifting points (e.g., transport lugs, specified lifting eyes). Improper lifting can cause serious injury and damage to the resistor.

**Safety measure:**

- Use only suitable lifting accessories/equipment with sufficient load capacity. Ensure that no device parts are loaded or damaged. The operator is responsible for the correct selection and attachment of the lifting equipment.



**WARNING!**

**Prevent cable damage**

Power and control cables must be routed only with an adequate bend radius.

- **RB = 10 × outer diameter (OD)** unless otherwise specified by the manufacturer.
- No bending directly at the cable gland: maintain at least **10 mm clearance**.

**Safety measure:**

- Before routing, verify cable marking (designation/manufacturer).
- Route the cable without tensile load and provide strain relief.
- Ensure protection against mechanical stress.


**WARNING — Do not route cables over sharp edges**

- Sharp edges or points can damage the cable insulation.
- This can lead to electric shock hazards and equipment failure.

**Safety measure:**

- Route cables only over deburred surfaces or through protected routing systems (e.g., cable ducts, protective conduits).
- Implement the required protective measures on site.






**WARNING!**

**Do not retighten or alter sealing threaded joints**

Factory-installed sealing threaded joints (sealing connections) on the resistor must not be altered, retightened, or loosened unless explicitly specified by the manufacturer. Otherwise, the sealing function may be impaired; leakage and equipment damage may occur. This applies in particular to coolant connections with a factory-integrated locking mechanism.

**Safety measures:**

- Do not manipulate sealing threads/joints.
- Only if authorized by the manufacturer: when loosening/reconnecting, ensure proper engagement of the locking mechanism.
- Use trained specialist personnel for cooling-system assembly work.
- Regularly check coolant connections for leaks.



**WARNING!**

**Working on pressurized units**

REO resistors with liquid cooling are pressurized.

**Safety measures:**

- Work may only be performed by qualified personnel.
- Before any disassembly (e.g., of threaded joints), depressurize the entire cooling circuit.
- Select hydraulic connections in accordance with applicable regulations and inspect them regularly.
- Verify the system is depressurized before starting work.
- Do not manipulate the device while residual pressure is present.
- Use suitable connection systems and operator-provided shut-off devices.
- Do not manipulate factory-installed sealing threaded joints; loosening/reconnecting only with manufacturer approval and verify locking engagement.

 **WARNING!**

**Do not move the unit by the cables**

Never use connection cables as lifting or carrying points.

- Doing so may damage the unit, in particular terminals, seals, or the electrical insulation.

**Safety measures:**

- Use approved lifting points only (e.g., tapped holes, transport/lifting lugs).
- Relieve cables mechanically and provide protection.
- Perform moving and positioning only with suitable lifting equipment.

**Note:** See also **Chapter 4 — Transport and Storage.**

 **WARNING!**

**Cable routing with clearance from hot surface**

The **enclosure surfaces** of REO resistors can exceed **250 °C (482 °F)** during operation.

- Cables routed too close to these hot components may overheat and lose insulation integrity.

**Safety measures:**

- Maintain a minimum clearance between cable and enclosure.
- In confined spaces, use temperature-resistant (high-temperature-rated) cables.
- Plan heat-remote routing (e.g., lateral, with shielding).

 **WARNING!**

**Hazard due to missing or illegible warning signs/labels**

Incomplete, damaged, or illegible warning signs/labels can prevent recognition of potential hazards. This can result in serious accidents with injuries up to and including death.

**Safety measures:**

- Ensure all warning signs/labels are in proper condition and clearly legible. The markings must unambiguously indicate existing hazards and withstand the operating conditions.
- Replace any missing, damaged, or illegible warning signs/labels immediately.
- For further information, see Chapter “Warning Signs.”



## WARNING!

### Danger due to improper installation

Improper installation work - e.g., use of unsuitable tools, incorrect screw joints, or failure to follow the assembly instructions - can cause components or the entire device to fall. This poses a significant risk to people and property.

#### Safety measures:

- **Wear appropriate personal protective equipment (PPE) during all assembly and disassembly work, e.g.:**
  - Safety footwear (at least S1),
  - Safety helmet,
  - Protective gloves.
  
- **Follow all instructions in the assembly manual carefully.** Use only the recommended tools and tightening procedures (e.g., torque specifications).



## WARNING!

### Property damage/fire hazard due to loose power connections

Inadequately secured power connections (e.g., incorrectly tightened screws or operational vibrations) can cause increased contact resistance. This may lead to overheating, device malfunctions, or a fire hazard.

#### Safety measures:

- Tighten all power connections to the torque values specified in the technical documentation.
- Use only suitable, calibrated tools for tightening.
- Check all power connections regularly for tightness — especially after transport, commissioning, or maintenance.



 **CAUTION!**

**Risk of injury due to sharp edges**

Despite edge deburring/smoothing, REO resistors are industrial components. There is a risk of injury when unpacking, carrying, installing, and mounting them.

**Precaution:**

- Wear suitable protective gloves and work with care. Avoid sudden movements when handling the device.

**NOTE - Use caution when removing packaging**

- Some devices are heavy, unwieldy, or have sharp edges. Careless unpacking can cause injury and product damage.

**Precaution:**

- Open the packaging step by step; ask a second person for help if necessary.
- Never lift devices by their connections, cables, or cooling connections.

 **CAUTION!**

**Equipment damage due to improper screwdriving**

Using unsuitable screw tools or incorrect screwdriving procedures can damage screw joints and enclosure parts, resulting in impaired function or device failure.

**Safety measures:**

- Use only tools with the correct size and drive/profile for the screw heads.
- Tighten all screws to the torque values specified in the technical documentation (use a calibrated torque wrench).
- Avoid over-torque and under-torque.

 **NOTE**

**Thermal switches/thermal sensors on the resistor**

Factory-installed thermal switches/sensors on the resistor are not intended to measure or monitor temperatures at the active part. They are used solely to monitor resulting temperatures at internal seals and cables.

**Safety measures:**

- If thermal sensors indicate excessive temperatures or a factory-installed thermal switch in the seal area trips (switching threshold exceeded), assume impermissibly high temperatures at the active part.
- Disconnect the device from the power supply immediately.
- Monitoring and evaluation of factory-installed thermal switches/sensors are the responsibility of the user/system operator.

## Intended use

REO products may be operated only in low-voltage systems, within the electrical, mechanical, and thermal limits specified in the technical data sheets and in compliance with the instructions stated therein.

The installation location must meet all environmental conditions and technical specifications given in the data sheet and in these instructions.

The units described are electrical equipment for use in industrial installations. Use in private households is not permitted.

## Applied directives and harmonized standards

When using products of **REO AG**, the following standards, directives, and legal regulations must be observed in their currently applicable versions:

- **DIN EN 61558** (series)
- **DIN EN 61800** (series)
- **German Product Safety Act (ProdSG)**
- **German Ordinance on Industrial Safety and Health (BetrSichV)**
- **DGUV regulations** of the German Social Accident Insurance
- **General VDE, DIN, EN, and IEC provisions**

To ensure proper function and avoid interference, the principles of **EMC-compliant installation** (electromagnetic compatibility) must also be followed.

### Technical standards (excerpt)

The following standards are relevant for the use and installation of the products. Depending on product type and application, additional specific standards may apply.

Norm	Title / Scope of Application
<b>DIN EN 60204-1 / VDE 0113-1</b>	Safety of machinery — Electrical equipment of machines
<b>DIN EN 60529 / VDE 0470-1</b>	Degrees of protection provided by enclosures (IP Code)
<b>VDI 2230</b>	Systematic calculation of high duty bolted joints
<b>DIN EN ISO 12100</b>	Safety of machinery - General principles for design - Risk assessment and risk reduction
<b>DIN EN 62444</b>	Cable glands for electrical installations
<b>DIN EN 50178</b>	Electronic equipment for use in electrical installations

### NOTE:

The selection, application, and compliance with the applicable standards lie with the user/operator. Depending on the intended use, industry, and system context, additional technical standards, directives, and legal requirements may apply and must be considered.

The directives and harmonized standards listed below were considered during the design and manufacture of the referenced products

Directive	Title	Applied Harmonized Standards
2014/30/EU	Electromagnetic Compatibility (EMC)	EN 61000-6-4:2019 EN 61000-6-2:2019
2014/35/EU	Low Voltage Directive (LVD)	EN 62477-1:2012 + A11:2014 + A1:2017
2011/65/EU	Restriction of Hazardous Substances (RoHS)	–



## Changes and Copyright

We reserve the right to make technical changes and to modify the content and structure of this documentation without prior notice.

The contents of this manual are protected by copyright. All rights, including reproduction, distribution, translation, microfilming, and storage and processing in electronic systems, are reserved by REO AG. Any use, including excerpts, requires the prior written consent of REO AG.

## 1.0 General

### 1.1 Product applicability and scope of this document

This operating manual applies to all electrical resistors manufactured by REO AG. It covers a wide range of designs, power classes, cooling concepts, and connection options.

The specific characteristics, operating limits, and connection details of the delivered unit are defined by the nameplate, the product data sheet, and the engineering specification provided by REO.

The products are designed for industrial use and may be deployed in various systems and applications provided the intended use, applicable technical limits, and the prescribed installation and environmental conditions are complied with.

**All resistors described in this manual have been designed and manufactured in accordance with the relevant European directives. When used as intended, they meet the requirements for CE marking. The CE mark is affixed to the nameplate.**

For certain series (e.g., BW 151, BW 152, BW 156), versions with UL certification/listing are available on request. Availability depends on the product configuration and order scope and must be agreed separately if required.

A full EU Declaration of Conformity (DoC) is available on request.

## 2.0 Functional description

### 2.1 Intended Use

Resistors manufactured by **REO AG** are electrical equipment designed to convert electrical energy into heat. They are used for:

- Current limitations
- Voltage reduction
- Attenuation of electrical signals
- Energy conversion
- Absorption of braking energy in electrical/electronic systems

#### Typical applications:

- Drive and converter systems
- Railway and power/energy technology
- Automotive engineering
- Industrial automation and control systems

The units are intended exclusively for installation in technical systems and equipment. The permissible electrical, thermal, and mechanical load limits as well as the degree of protection (IP code) are specified in the product-specific data sheets and must be strictly observed.

## 2.2 Requirements for proper use

Operation is permitted only if the following conditions are met:

- Compliance with the operating limits specified in the data sheet (voltage, current, temperature, environmental influences).
- Use only at designated, suitable installation/installation locations.
- Installation, commissioning, and operation only by qualified personnel.
- Use only in environments that correspond to the product's degree of protection (IP code).

## 2.3 Improper use

The following cases constitute **improper use** in particular:

- Operation outside the specified limits.
- Use in potentially explosive areas without appropriate approval/certification.
- Use in unauthorized industries/application domains or under impermissible environmental conditions.
- Improper mechanical impact or unauthorized modification/tampering.
- Use for purposes other than intended, e.g., as a general heating element.

### **WARNING:**

Failure to observe the intended use may lead to overheating, device damage, fire hazard, and danger to persons.

REO AG accepts no liability for damage resulting from improper use.

### **NOTE:**

These instructions also apply to water-cooled resistors from REO AG.

Use is permitted only in closed and monitored water circuits. The pressure and temperature limits of the cooling medium specified in the data sheet must be strictly observed.

## 3.0 Technical Data

The technical characteristics of REO resistors vary by series, size, power range, and intended use. Only the product-specific information given in the data sheet, nameplate, and conformity documents is binding. These requirements must be observed during planning, selection, installation, and operation. The data sheet supplied with the product is authoritative for safe use. In case of uncertainty or special applications, consult REO AG Technical Support and obtain project-specific approvals.

Unless otherwise specified, the following applies:

- Permissible ambient temperature: max. 40 °C (104 °F). Above this, continuous power must be derated by 5% per 10 K temperature rise.
- Permissible installation altitude: 0 m to 4,000 m above sea level. From 1,000 m, continuous power  $P_b$  must be derated by 5% per 1,000 m.
- Mounting position: vertical suspended with connections facing downward or horizontal. → See Chapter 5 “Installation.”

For water-cooled versions, the following product-specific limits also apply (see data sheet):

- Permissible coolant pressure
- Coolant temperature range
- Coolant quality requirements

### 3.1 Duty cycle and overload factors

The continuous power  $P_b$  is lower than the maximum permissible pulse power ( $P_{max}$ ), by an application/product-dependent factor (see data sheet). REOhm braking resistors are designed for intermittent duty; typical cycle time: 120 s.

Thanks to their winding geometry and material compaction, REOhm braking resistors can absorb and store energy for short periods and efficiently dissipate heat to the surface. This provides thermal relief during pause times. With rapid cooling, pulse loads do not damage the winding body if the permissible limits are observed.

The standard series are suitable for duty cycles from 1% to 100%. Variants with lower duty cycles and/or shorter cycle times are available on request.

### 3.1.1 Mathematical Relationship

If the kinetic energy ( $E_{kin.}$ ) dissipated in the resistor during braking is known, the required continuous power follows from the energy and the cycle time  $SD$ :

#### a) From energy per cycle

$$P_D = E_{kin.} / SD:$$

with  $E_{kin.}$  in J and  $SD$ : in s  $\Rightarrow P_D$  in W.

#### b) From duty cycle (ED) / overload factor

If  $E_{kin.}$  is unknown, the **overload factor**  $K_{OL}$  can be calculated from the **duty cycle**  $ED$  and the cycle time  $SD$ :

- $ED[\%] = ED[s] / SD[s] \times 100$
- **Overload factor** =  $100 / ED \%$  (\*)
- **Overload factor** =  $P_{max} / \text{continuous power } P_D$  OR  $P_{max} = \text{continuous power } P_D \times \text{overload factor}$

**Definitions:**  $P_D$  ... continuous power;  $P_{max}$  ... maximum permissible pulse power;  $SD$  ... cycle time;  $ED$  ... duty cycle.

### 3.1.2 Examples

#### Calculating permissible continuous power for limited duty cycle

The permissible continuous power  $P_D$  for intermittent operation follows from duty cycle  $ED$  and overload factor  $K_{OL}$ :

- Duty cycle 10%, overload factor 10:

$$P_D = P_{max} \times 0,10 \quad \text{with overload factor 10: } P_{max} = 10 \times P_D$$

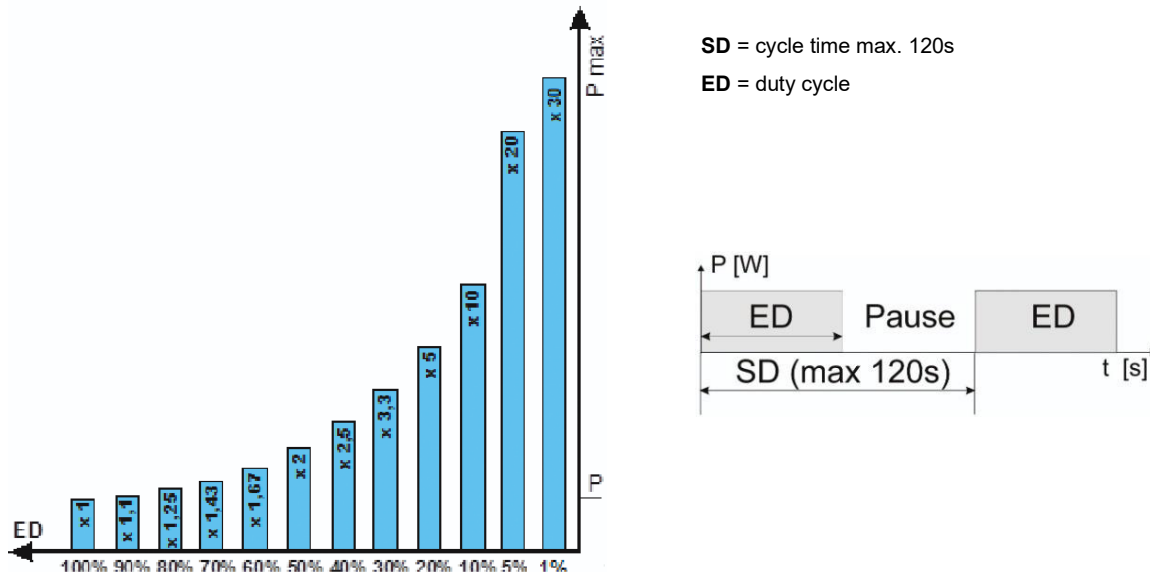
- Duty cycle 50%, overload factor 2:

$$P_D = P_{max} \times 0,50 \quad \text{with overload factor 2: } P_{max} = 2 \times P_D$$

#### Definitions:

- $P_D$  permissible continuous (average) power over the cycle
- $P_{max}$  maximum permissible pulse power during the ON interval
- The overload factor is calculated from the reciprocal of the duty cycle (e.g., 10 % = factor 10)

### 3.1.3 Load curves for air-cooled resistors



#### Permissible duty cycles for air-cooled REO resistors

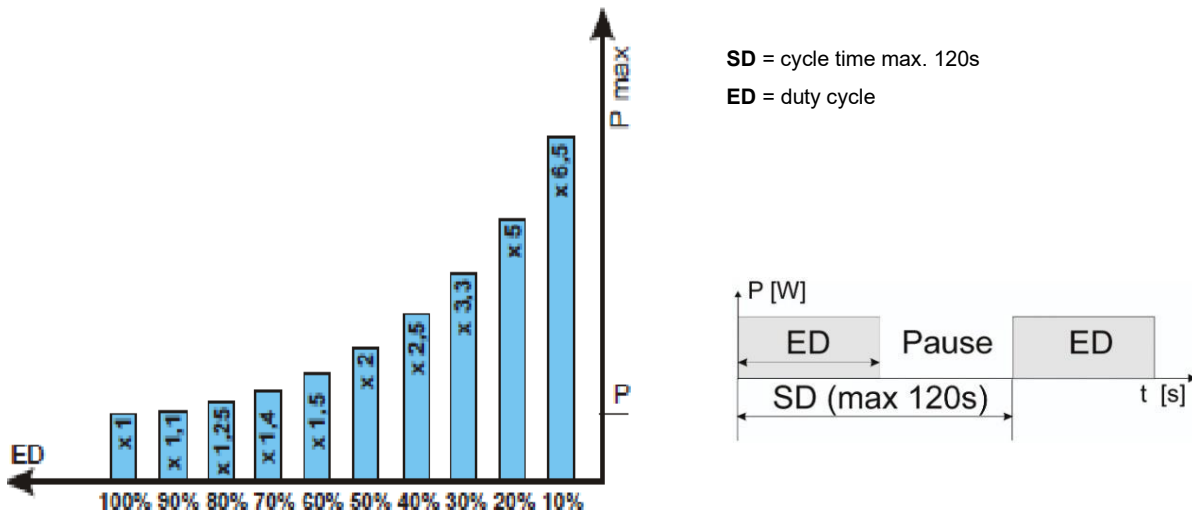
For air-cooled REO resistors, **duty cycles ED** from **1% to 100%** are permissible. The following applies:

- At **1% ED**, the **maximum overload factor K<sub>OL</sub> max** is **30**.
- At **100% ED**, the overload factor is **1** (continuous operation without overload).
- **Shorter duty cycles (< 1%)** are **available on request**.

\* The formula for calculating the overload factor shown in section 3.1.1 is applicable to duty cycles in the range from **5% to 100% ED**.

For duty cycles **below 5% ED**, the **overload factor 30** is specified as the maximum permissible value.

### 3.1.4 Load Diagrams for Water-Cooled Resistors



#### Permissible duty cycles for water-cooled REO resistors

Water-cooled REO resistors are permissible for duty cycles between 10% ED and 100% ED. The following factors apply:

- at 10% ED: maximum permissible **overload factor 6.5**
- at 100% ED: **overload factor 1** (continuous operation)

**Note:** Shorter duty cycles (< 10%) are available upon request.

The specified values apply in particular to series **BW D 158** and **BW D 160**.

For series **BW D 330**, neither the mathematical relation described in Section 3.1.1 nor the corresponding load diagram applies. This resistor is designed for continuous operation. A permissible pulse load may be requested and technically verified on a case-by-case basis.

\*The formula described in Section 3.1.1 for calculating the overload factor applies to duty cycles between **20% and 100% ED**.

For duty cycles in the range of **10% to < 20% ED**, the maximum permissible overload factor is **6.5**.

## 4.0 Transport and Storage

### Note on transport and storage

REO AG resistors are precision-manufactured electrical components that are assembled and quality-tested under controlled conditions.

To ensure correct electrical and mechanical performance, appropriate protective measures must be applied during transport and storage.

### 4.1 Transport

#### Transport instructions

- The resistors must be transported so that they are protected against shock and vibration.
- Mechanical impacts such as shocks, deformation of the cooling profiles, and tensile loads on electrical connections must always be avoided.
- The products shall not be thrown or stacked, unless stacking has been expressly approved in writing by REO.
- The original packaging provides optimum product protection and shall be retained until installation.

#### Ambient conditions during transport:

- Permissible transport temperature range:  $-15\text{ °C}$  to  $+70\text{ °C}$  (short-term), in accordance with IEC 60068-2-1 / IEC 60068-2-2, unless otherwise specified by REO.
- Permissible relative humidity: max. 85 % RH, non-condensing, in accordance with IEC 60068-2-30, unless otherwise specified by REO.



#### Additional notes for air and sea freight

During air or sea transport, large temperature fluctuations may occur and can lead to condensation inside the packaging.

To prevent moisture ingress caused by humidity or diffusion, the following measures are required:

- Include suitable desiccants (e.g., silica gel) in sufficient quantity
- Use diffusion-proof packaging, e.g., aluminum composite foil

#### The quantity of desiccant depends on:

- the expected transport duration
- the packaging volume
- the climatic conditions during transport

## 4.2 Storage

### 4.2.1 Storage conditions

Storage must only occur in dry, enclosed rooms with controlled humidity.

Storage in direct sunlight or near heat sources must be avoided.  
Corrosive or chemically aggressive atmospheres (e.g., caused by oils, solvents, or vapors) must also be excluded.

#### Permissible storage conditions:

- Temperature range:  $-15\text{ °C}$  to  $+70\text{ °C}$  (maximum temperature change:  $20\text{ K/h}$ ), in accordance with IEC 60068-2-1 / IEC 60068-2-2, unless otherwise specified by REO.
- Relative humidity: up to  $85\text{ \% RH}$ , non-condensing, in accordance with IEC 60068-2-30, unless otherwise specified by REO.

### 4.2.2 Note on moisture absorption and insulation resistance

#### Note on moisture absorption during prolonged storage

Some REO AG resistor series contain encapsulation materials and seals which, despite their high degree of protection, may be permeable to water molecules over time. This effect is due to the physical properties of the materials and particularly affects seals and insulation layers.

Even during prolonged storage under specified climatic conditions (e.g., low humidity), moisture can diffuse into the component, which may cause a temporary reduction in insulation resistance.

Switching on the braking resistor when it is damp or not completely dry carries the risk of short circuits, potentially causing damage to the resistor and the connected system.

The resistor may only be put into operation when it is completely dry (free of moisture or condensation).

#### See also:

- Chapter: Safety information
- Chapter 5: Installation

Resistors with visible moisture ingress (e.g., due to condensation, leakage currents, or insulation faults) must not be put into operation until they are:

- Completely dry, and
- The insulation resistance meets the product-specific limit values.

### 4.2.3 Long-term Storage

The braking resistor is only suitable for short-term storage of up to 1 year (in accordance with IPC/JEDEC J-STD-033).

The installation position described in Section 5.2.2 must also be fully complied with during this period.

If stored for more than one year, physically unavoidable diffusion processes may cause changes in the electrical properties of the braking resistor.

In particular, moisture penetration through diffusion or contact with liquids on the resistor housing can impair internal insulation and lead to a reduction in insulation resistance.

Operation is not permitted if the insulation resistance falls below  $R_i \leq 5 \text{ M}\Omega$  at a measuring voltage of 1000 V.

In this case, there is a risk of:

- **Short circuits**
- **Voltage flashovers**
- **Dangerous potentials on the housing**
- **Damage to adjacent systems**

#### **Measures to be taken before commissioning after long-term storage:**

To restore the insulation resistance, it is recommended that the braking resistor be subjected to oven drying before installation/commissioning:

- **Duration:** at least 4 hours
- **Drying temperature:** maximum 100 °C
- **Temperature change:** max. 20 K/h during heating and cooling

Subsequently, a new insulation resistance test must be performed. Operation may only take place if the specified limit values are reached again.



#### **Note on commissioning**

The insulation resistance must be at least 5 MΩ.  
Resistors with an insulation resistance below 5 MΩ must not be put into operation. If necessary, repeat the oven drying process.

See also: **Chapter 5: Assembly / Installation / Commissioning**

#### 4.2.4 Storage of liquid-cooled resistors

If a liquid-cooled resistor is not operated for an extended period or is taken out of service for storage, the following measures must be taken:

- **The cooling circuit must be completely emptied.**
- **At ambient temperatures below freezing, the cooling circuit must also be blown out with dry compressed air to prevent frost damage.**
- **The resistor must not be actively cooled during storage.**

When using a cooling liquid with a temperature ( $T_{in}$ ) below the ambient temperature ( $T_u$ ), there is a risk of condensation, especially when cooling is active without electrical load.

Operation in this configuration is not permitted unless expressly approved by REO.

Water-cooled resistors must always be drained for storage and transport and kept in a dry condition.



**Caution:**

Residual moisture in the cooling circuit can lead to corrosion or frost damage.  
The circuit must be completely drained and blown out before storage or transport.

## 5.0 Assembly / Installation / Commissioning

### 5.1 General Information

Assembly and electrical installation may only be carried out by qualified personnel in accordance with applicable national and international regulations.

Before assembly, check that:

- **The resistor is mechanically undamaged, and**
- **The type label is completely legible.**

Resistors with visible damage or deformation must not be used.

The conditions at the installation site must comply with the protection classes and operating limits specified in the product data sheet.

Before starting assembly, read and observe both the product data sheet and these instructions in full.

### 5.2 Mechanical Assembly

The resistor must be mounted without tension, form-fitting, and vibration-proof. Only the mounting holes provided on the heat sink or housing may be used for this purpose.

When fastening water-cooled resistors, it must also be ensured that:

- **Hydraulic connections are mounted free of tension and pressure, and**
- **Coolant lines do not transmit any mechanical forces to the housing or connections.**

#### 5.2.1 Clearances and Minimum Distances

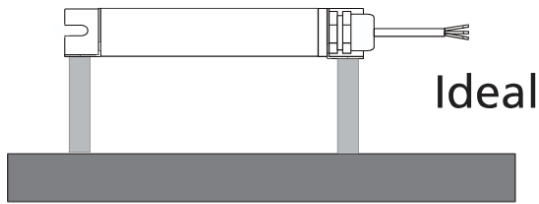
To ensure adequate convection and heat dissipation, the following minimum distances to adjacent components must be observed, unless otherwise specified by REO:

Installation direction	Minimum distance
Top	> 200 mm
Bottom	> 100 mm
Side	> 25 mm

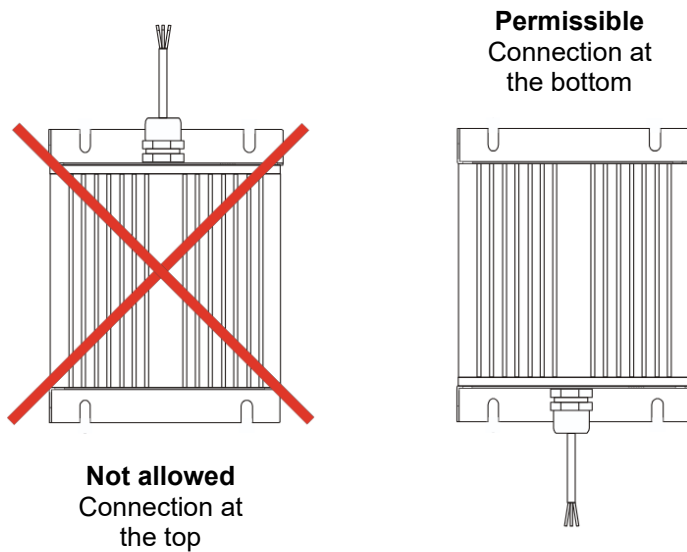
The heat energy generated by the braking resistor must be dissipated unhindered. Flammable materials or substances must not be installed or stored in the immediate vicinity of the resistor.

## 5.2.2 Installation Position

Unless expressly specified or approved otherwise by REO, the following requirements must be observed when installing the resistor:



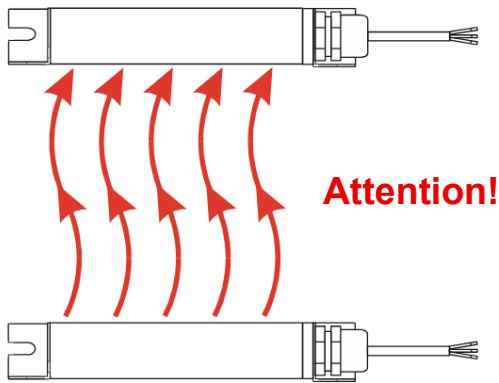
When mounting on a heat-insulating or poorly heat-conducting substrate, the resulting heating of the resistor must be checked due to limited heat dissipation. The resistor must be mounted in such a way that heat dissipation (e.g., through natural or forced convection) is not impeded.



The installation position must correspond to the position specified in the product data sheet or technical specification (e.g., horizontal, vertical, wall-mounted). For vertical mounting, it is essential to ensure that the connections or terminals are located on the underside of the resistor.

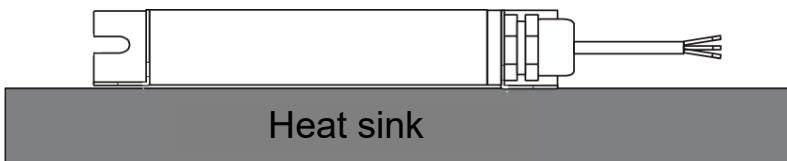
An installation position with the connections on the top is not permitted.

A different mounting orientation is only permitted with the written approval of REO.



**Attention!**  
Mutual influence

If several resistors are mounted on top of each other or in close proximity, the mutual thermal influence must be taken into account. In this case, the specified ambient conditions must be strictly observed, and the installation situation on site must be verified. It must be ensured that no heat is transferred to adjacent components unless they are specifically designed for this purpose.



Performance increase by a factor of 1.5 - 4 possible

Direct mounting of the resistor on a suitable heat sink or thermally conductive mounting surface can increase the continuous power or reduce the surface temperature.

Depending on the type, size, and thermal conductivity of the cooling surface, the permissible continuous power of the resistor may be increased by a factor of 1.5 to 4, provided this has been verified by REO.

For water-cooled versions, the hydraulic connection must be made according to the intended flow direction and position.

**Note:** The actual increase in power must be verified in each individual case. The ambient conditions and limit values specified in the product data sheet remain valid and must be observed.

**Note:** When mechanically connecting the resistor to the heat sink, the tightening torques, screw strength class, and fasteners used (e.g., washers, spring washers) must be selected and implemented professionally in accordance with VDI 2230 and, if applicable, manufacturer-specific specifications for the fasteners. The user or plant operator is responsible for selecting fasteners that comply with the standards and for installing them correctly.

## 5.3 Electrical installation

### 5.3.1 Safety Principles

When working on electrical equipment, the **“5 safety rules” according to EN 50110-1 must be observed:**

1. **Disconnect**
2. **Secure against reconnection**
3. **Check that there is no voltage**
4. **Ground and short-circuit**
5. **Cover or fence off adjacent live parts**

### 5.3.2 General Connection Specifications

- The electrical connection must be made by professionally connecting to customer-supplied terminals, connection strips, or busbars in accordance with the applicable electrical engineering regulations (e.g., DIN VDE 0100).
- The strain relief and mechanical protection of the cable routing must be provided by the customer.
- If the connection cable is openly accessible, contact protection must be ensured by suitable measures.
- The cable entry must be protected against moisture penetration (e.g., by means of an IP-compliant cable gland in accordance with IEC 60529).
- The wires must not be subjected to mechanical stress; tension-free cable routing is essential.
- The protective conductor (PE) must always be connected first and disconnected last.
- When laying the connection cables, the manufacturer's minimum bending radii must be observed. The name and manufacturer of the cable are printed on the cable. If neither REO nor the manufacturer provide information on the minimum bending radius, the following applies:  
Minimum bending radius  $R_B = 10 \times$  outer diameter of the cable

### 5.3.3 Insulation Requirements and Moisture Protection

- Electrical insulation must be ensured even in the event of condensing humidity or coolant leaks (in liquid-cooled systems).
- If the resistor comes into contact with coolant (e.g., during installation, removal, or due to adjacent systems), the following measures must be carried out:
  - Drying of the component
  - Testing of the insulation resistance
  - The insulation resistance must be at least 5 M $\Omega$  at 1000 V.

### 5.3.4 Mechanical connections and tightening torques

- Use only the tightening torques specified for the respective connections.
- Refer to the product data sheets or the technical data sheets of the connection components for the applicable tightening torques.
- For threaded connections (e.g., coolant lines), ensure that factory-installed connection components are secured against unintentional loosening (e.g., by locking devices).
- Improper tightening torques (too low or too high) can lead to contact problems, overheating, or equipment damage.
- The responsibility for proper and standards-compliant installation rests with the system operator.

### 5.3.5 Electrical installation for resistor combinations / existing terminals

For REO resistors combined into a unit with common connection terminals, the following steps must be observed:

1. Prepare the cable:
  - Select the conductor cross-section according to current-carrying capacity and data sheet
  - Use suitable cable lugs or ferrules
  - Dimension cable lengths so that there is no tensile stress and sufficient bending allowance
2. Make the electrical connection according to terminal designation and circuit diagram
3. Tighten terminals with the specified tightening torque
4. Check strain relief and mechanical protection
5. Final inspection: visual check, insulation measurement, protective conductor test

Only approved connecting devices may be used. Cable ends must comply with DIN 46234 / DIN 46235 / DIN 46228. Processing must be carried out in accordance with the applicable VDE standards (e.g., VDE 0298-4).

- Multiple occupancy of terminals is not permitted unless expressly approved for this purpose.
- Screw connections must be retightened after the first thermal cycle (heating).
- Conductors must not be subjected to tensile or bending stress – if necessary, mechanical strain relief must be provided.

### 5.3.6 Tightening torques for connection terminals and cable glands

The following tightening torques apply to the connection terminals installed on REO resistors, depending on the respective conductor cross-section:

Conductor cross-section [mm <sup>2</sup> ]	Torque [Nm]
1.5	0.22...0.25
2.5	0.5...0.6
4	0.5...0.8
6	1.5...1.8
10	1.5...1.8
16	2.5...3.0
35	3.2...3.7
50	6...8
95	15...20

The specific terminal type and the corresponding conductor cross-section are specified in the product-specific REO data sheet.

The use of a calibrated torque screwdriver is strongly recommended in order to:

- ensure secure contact,
- prevent overheating,
- and comply with mechanical strength requirements.

#### Permissible connecting devices:

For cable connection technology (e.g., crimping, ferrules, cable lugs), only connectors standardized according to DIN/VDE may be used:

- DIN 46228 – Ferrules
- DIN 46235 – Cable lugs
- VDE 0603-1 / DIN EN 60998 – Connection terminals



#### Caution:

Improperly tightened terminals - e.g., with too little or too much tightening force, can lead to contact problems, thermal overload, and equipment damage.

**The responsibility for proper and standards-compliant installation rests with the system operator.**

## Factory-fitted cable glands

Some REO resistors are equipped with factory-fitted cable glands or bushings, particularly on terminal boxes or on individual profiles.

These factory-installed glands are part of the certified overall system and must **not** be opened, modified, replaced, or retightened by the user.



Modifications by the user may compromise the IP protection rating, electrical safety, and CE conformity of the product and will void the warranty.

For cable glands on terminal boxes that are intended for user access (e.g., user power supply/discharge, temperature sensors if applicable), the tightening torques specified by the cable-gland manufacturer apply, depending on the size.

Please refer to the following table for the permissible values:

Size (metric)	Max. tightening torque [Nm]
M12x1,5	6
M16x1,5	8
M20x1,5	10
M25x1,5	10
M32x1,5	15
M40x1,5	20

## 6.0 Operation

### 6.1 General information

Separate activation or switch-on of the product is not required.

REO resistors are passive through-elements and begin operating as soon as they are mechanically fastened and all peripheral components are correctly connected.

Operation is considered **normal** as long as:

- sufficient power supply is ensured,
- cooling is performed according to the specifications,
- no interference signals or malfunctions are detected.

Malfunctions can be identified and assessed during maintenance or inspection.

### 6.2 Notes for water-cooled versions

Before commissioning a water-cooled resistor, the closed cooling circuit must be checked for the following parameters:

- Tightness of all connections
- System pressure according to the manufacturer's specifications
- Coolant flow rate



**Warning:**

Commissioning without sufficient coolant flow or with air pockets in the system can cause damage to the resistor due to overheating.

### 6.3 Requirements for forced cooling

For forced cooling (e.g., liquid or fan cooling):

- The cooling system must be activated before the resistor is operated under load.
- Cooling must continue after the load is removed until the heat stored in the resistor has been completely dissipated.

Unless otherwise specified by REO, the minimum cooling run-on time under load conditions is:

- 60 minutes (1 hour)

### 6.4 Operational Monitoring

Operational monitoring by the product itself is **not provided**.

Monitoring of the operating parameters (e.g., temperature, flow rate, supply voltage) must be performed on-site.

## 7.0 Cleaning / Maintenance / Servicing

### 7.1 Cleaning

REO resistors must be cleaned according to the degree of contamination.

Contaminants (e.g., dust, deposits, cooling residues) can impair heat dissipation or electrical properties and must therefore be removed regularly.

- Use dry or slightly damp, non-conductive cleaning agents.
- Cleaning while energized is **not permitted**.
- Avoid liquids entering the housing or connection areas.
- For water-cooled versions, check the cooling circuit for residues, leaks, or biological deposits.

### 7.2 Maintenance

To ensure operational safety and functionality, the operator must perform **regular inspections**.

- Inspection at least **once per year** is recommended.
- In particular, the following points must be checked as part of maintenance:
  - Secure fit of all mechanical and electrical screw connections
  - Wear or corrosion at connection points or fastenings
  - Condition of seals, lines, and insulating materials
  - For water-cooled versions: flow rate, pressure, tightness of the cooling circuit

### 7.3 Servicing

- Shorter maintenance and cleaning intervals may be required on-site depending on the operating environment (e.g., increased dust, humidity, or vibration).
- The operator is responsible for defining and implementing a suitable maintenance program in accordance with requirements.



**Note:**

Lack of or insufficient maintenance can impair the service life and functional reliability of the product and may void warranty claims.

## 8.0 Malfunctions and Troubleshooting

### 8.1 General information

REO resistors are generally maintenance-free and designed for long-term operation under the specified ambient conditions. If malfunctions, irregularities, or abnormalities occur during operation, the device must be immediately disconnected from the power supply. The cause must be analyzed by qualified technical personnel.

### 8.2 Typical Malfunctions and Countermeasures

Symptom	Possible Cause	Recommended Countermeasure
<ul style="list-style-type: none"> <li>Smoke or odor development</li> </ul>	<ul style="list-style-type: none"> <li>Overload</li> <li>Thermal overload</li> <li>Short circuit</li> </ul>	<ul style="list-style-type: none"> <li>Switch off the device immediately</li> <li>Check the resistor for external damage</li> <li>Inspect connections and application</li> </ul>
<ul style="list-style-type: none"> <li>Discoloration of housing or heat sink</li> </ul>	<ul style="list-style-type: none"> <li>Long-term overload</li> <li>Insufficient cooling</li> </ul>	<ul style="list-style-type: none"> <li>Check ambient temperature</li> <li>Ensure proper cooling conditions and convection</li> </ul>
<ul style="list-style-type: none"> <li>Noticeable operating noises (e.g., humming, crackling)</li> </ul>	<ul style="list-style-type: none"> <li>Partial discharges due to moisture</li> <li>Insulation faults</li> </ul>	<ul style="list-style-type: none"> <li>Measure insulation resistance</li> <li>Drying may be necessary</li> </ul>
<ul style="list-style-type: none"> <li>Measured values outside tolerance</li> </ul>	<ul style="list-style-type: none"> <li>Aging</li> <li>Overload</li> <li>Contact issues</li> </ul>	<ul style="list-style-type: none"> <li>Measure insulation resistance</li> <li>Check terminals and connections</li> <li>Replace device if necessary</li> </ul>
<ul style="list-style-type: none"> <li>Moisture ingress</li> <li>condensation</li> </ul>	<ul style="list-style-type: none"> <li>Incorrect storage or installation environment</li> </ul>	<ul style="list-style-type: none"> <li>Dry the unit</li> <li>Check for leaks</li> <li>Check the ambient climate</li> </ul>

### 8.3 Actions in Case of a Fault

- The device must be immediately disconnected from the power supply.
- A visual inspection must be performed to check for mechanical damage, deformation, discoloration, leaks, or obvious defects.
- Electrical measurements (e.g., insulation testing) may only be carried out by qualified personnel.

After diagnosing the fault, verify that all technical operating limits specified in the data sheet (e.g., power ratings, temperature, cooling specifications, protection class) have been observed.

The device may only be returned to operation once the cause has been clearly identified and rectified.



**Warning:**

A damaged, deformed, or thermally overloaded resistor must not be put back into operation. There is a risk of fire, electric shock, or device damage.

**Before returning the unit or performing extensive fault analysis, contact REO AG in advance.**

## 9.0 Disassembly and Disposal

### 9.1 Safety during disassembly

Before starting disassembly, the following safety measures must be observed:

- The device must be completely disconnected from the power supply.
- Appropriate measures must be taken to prevent accidental reconnection.
- Residual electrical charges (e.g., in DC links or capacitors) must be safely discharged before disconnecting electrical connections.
- Disassembly work may only be performed by qualified personnel in accordance with applicable regulations.

**Caution:**

Resistors may still be hot after being switched off.  
There is a risk of burns from residual heat.

**Warning:**

Improper disassembly can lead to electrical hazards, fire hazards, or damage to adjacent systems.

### 9.2 Disposal

**Disposal of REO resistors is subject to the following requirements:**

- **EU Directive 2012/19/EU (WEEE)** – Waste Electrical and Electronic Equipment
- **ElektroG** – German law on placing on the market, return, and environmentally sound disposal of electrical and electronic equipment

**Principles of disposal:**

- The product must not be disposed of with household waste.
- Disposal must be carried out only by certified disposal companies or municipal collection points.

**Separation of recyclable materials:**

The following components must be separated by material or recycled where technically possible:

- Aluminum components (e.g., housing, heat sinks)
- Copper wires and connection strands
- Connection terminals
- Insulation materials, sealants (e.g., silicone)

**Packaging materials:**

- Packaging is recyclable and must be disposed of according to local packaging waste regulations.

	<b>Name</b>	<b>Signature</b>	<b>Date</b>	<b>Department</b>	<b>Position</b>
<b>Created</b>	C.Wrzesinski		May 7, 2025	KO	Design
<b>Reviewed</b>			May 9, .2025	QM	Quality Management
<b>Approved</b>	S. Reimann		May 9, 2025	EW	Head of Technology

Rev.	Amended by	Date:	Additions / Revisions	Reviewed by	Date:
01	Wrzesinski	July 15, 2025	Design, structuring, warnings		



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