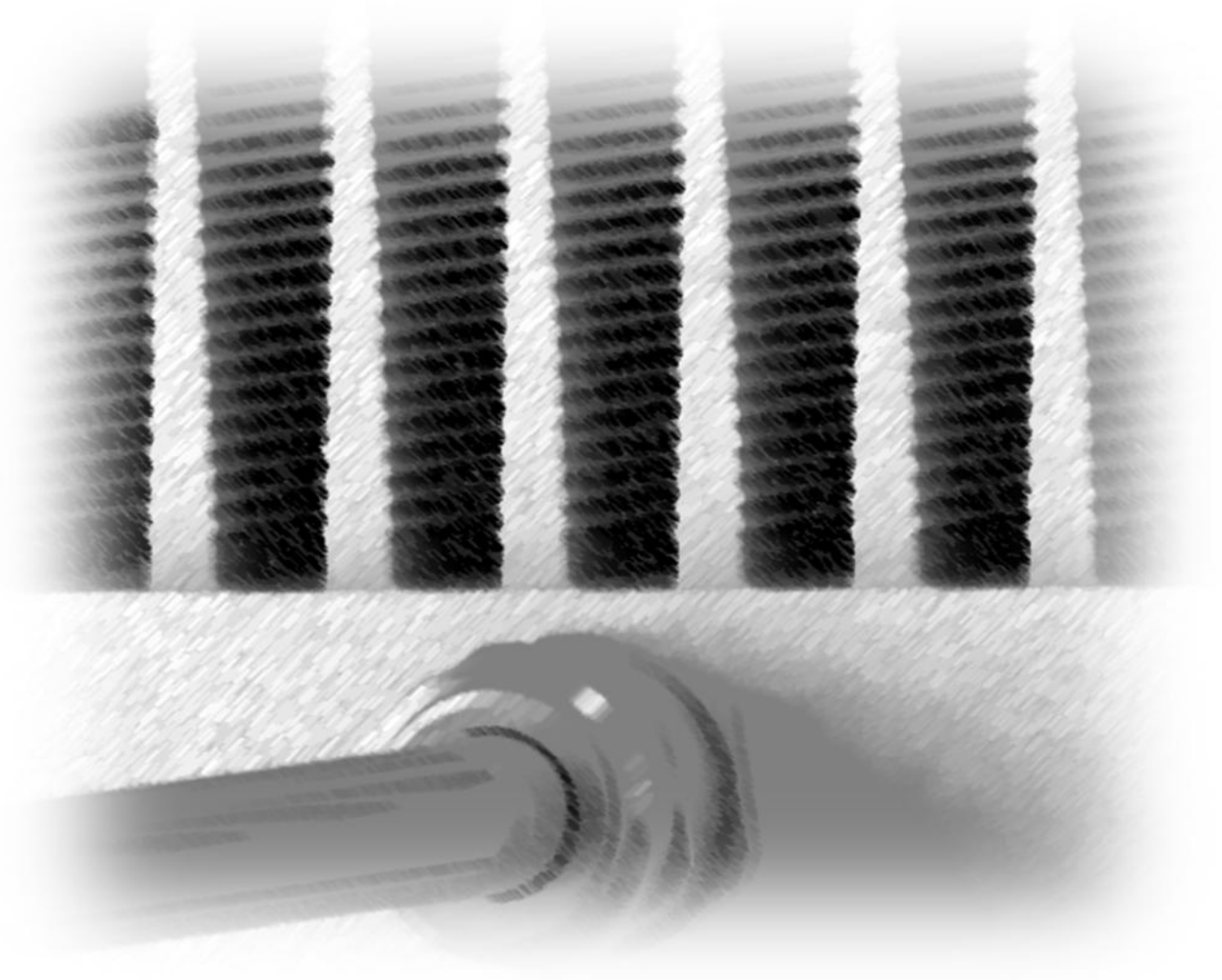

Operating Instructions

REOhm Resistor

REOhm_Widerstand_rev01.en
10.03.2026

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Safety Instructions for the User

Important Note!

READ CAREFULLY BEFORE USE AND KEEP FOR FUTURE REFERENCE

These instructions contain all the information required for the proper use of the products described. They are intended exclusively for qualified personnel.

Qualified personnel are persons who, due to their professional training, experience, and instruction in the specific field of drive and electrical engineering, as well as their knowledge of relevant standards, regulations, accident prevention regulations, and operational procedures, have been commissioned by the operator to perform the necessary tasks. These persons must be able to recognize potential dangers and implement appropriate protective measures. Definition of qualified personnel is contained in VDE 1000-10; DIN EN 50110-1 (VDE 0105-1).

It must be ensured that all basic planning work on the machine or system, as well as all activities related to transport, assembly, installation, commissioning, maintenance, and repair, are carried out by qualified personnel or supervised by appropriately responsible specialists.

The following points in particular must be observed:

Safety Instructions for Assembly and Commissioning

The following instructions must be observed during all work related to assembly, installation, commissioning, maintenance, and repair:

- **Compliance with technical data and permissible areas of application**, as specified in catalogs, order documents, type plates, and product labels, for example.

- **Observe general installation and safety regulations**, in particular the applicable standards (e.g., VDE regulations, DIN standards) and legal requirements.

- **Take local and system-specific requirements into account**, in particular with regard to electrical protective measures, ambient conditions, and access regulations.

- **Professional use of suitable tools and lifting and transport equipment** to prevent damage and dangers.

- **Use of personal protective equipment (PPE)** in accordance with the applicable occupational safety regulations.

- **Compliance with the specified installation conditions**, in particular:
    - Ensuring the necessary protection against contact during operation,
    - Protection against electric shock caused by unintentional touch (e.g., covers).

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

DANGER!

Installation and electrical connection - risk of fatal electric shock

Installation or wiring of the device while energized or without proper grounding may result in electric shock, severe injury or death, destruction of the device, or damage to adjacent systems.

Safety measures:

- Only install or connect the device when it is de-energized and grounded.
- Before starting work, check that the power is off and secure it against being switched back on.
- When connecting the power supply, always connect the protective earth conductor (PE) first and disconnect it last.
- Installation and maintenance may only be carried out by qualified personnel.

DANGER!

Fire and explosion hazard due to high surface temperatures

REO resistors can reach housing temperatures of over 250 °C. The device must not be operated in flammable or potentially explosive environments (e.g., with combustible gases or aerosols). There is a risk of fire and explosion.

Warning - Thermal hazard:
Thermal effects resulting from the surface temperature of the resistor (e.g. overheating, thermal deformation or material degradation) on mounting surfaces or adjacent components are the responsibility of the system operator.

Warning – Risk of burns:
Contact with hot surfaces may cause injury due to burns.

Safety Measures:

- Do not operate the device in flammable or explosive areas.
- Maintain sufficient clearance to combustible materials.
- Verify the temperature resistance of mounting surfaces.
- Provide suitable protection against accidental contact.
- Apply a warning label “Hot surface”.
- Allow the device to cool down sufficiently before performing any work.

WARNING!

Operation in unsuitable environment

Storage, transport, installation or operation in an unsuitable environment may damage the device. This also applies to open cable or conductor ends.

Safety Measures:

- The maximum permissible IP protection class is specified on the type label of the resistor and in the product data sheet (DIN EN 60529).
- Failure to observe this can result in electric shock or damage to the device.

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WARNING!

Insufficient cooling

To prevent overheating and damage to the device, the specified environmental conditions must be observed. This includes ensuring sufficient air exchange during natural cooling and activating forced cooling before switching on, during operation, and after switching off the device.

Switching on forced cooling too late or switching it off too early can lead to permanent damage to the device. If cooling is not carried out as specified, the electrical insulation and the IP protection rating of the resistor may be impaired or destroyed. This poses a risk of electric shock and damage to adjacent systems.

Even after the resistor has been switched off, the heat energy stored in the active part is transferred to the housing. In forced-cooled devices in particular, this can cause internal seals to heat up to an impermissible temperature level if the forced cooling is deactivated too early.

Safety Measures:

- Ensure forced cooling is activated before switching on the device.
- Maintain forced cooling continuously during operation.
- Continue forced cooling for a sufficient period of time after switching off.
- Unless otherwise specified, the forced cooling run-down time is at least 1 hour.
- Observe the ambient conditions specified in the data sheet.

WARNING!

Damage caused by mechanical impact

Blunt force, blows, or unspecified forces can damage the device. This can impair or destroy its function, IP protection rating, and primary insulation. In this case, there is a risk of electric shock and the possibility of damage to adjacent systems.

Safety Measures:

- Do **not** mount, operate, or energize devices that are deformed or visibly damaged.
- Observe the specified torque values for terminals as indicated in **Chapter 5.0 “Assembly / Installation / Commissioning”.**

WARNING!

Risk of electric shock caused by device manipulation

Improper interventions can result in damage, malfunction, loss of IP protection, and impairment of electrical insulation. This can lead to electric shock or further damage to the device.

Safety Measures:

- Screw connections, rivet connections, cable glands, piping, clamp connections, cable guides, hydraulic connections, or attachments on the resistor must not be loosened, modified, manipulated, or replaced.

WARNING!

Risk of injury during transport and installation

Transporting, lifting, or installing the device at points not intended for this purpose is strictly prohibited. Non-compliance may result in personal injury, damage to the device, or damage to adjacent systems.

Safety Measures:

- Use all existing lifting eyes, attachment points, or specified lifting positions (e.g., threads or holes for lifting eyes).
- The customer is responsible for ensuring that any auxiliary equipment such as chains, ropes, or lifting beams has sufficient load capacity and is secured in a manner that prevents damage to the resistor or its components.

WARNING!

Operation in unsuitable networks or applications

Installation, connection, and operation of the resistor in unsuitable network types or applications is not permitted. Failure to comply may result in electric shock and serious injury. In addition, there is a risk of destruction of the device or damage to adjacent systems.

Safety Measures:

- Only connect the device to the specified network types in accordance with the data sheet and manual.
- Installation and connection must be carried out exclusively in accordance with the manufacturer's instructions.
- Before commissioning, check whether the application is approved for use with the resistor.
- Installation and maintenance may only be carried out by qualified personnel.

WARNING!

Damage due to improper cable routing

Damage to cables, impairment of sealing function, loss of IP protection, and risk of electric shock can occur if minimum bending radii are not observed or if connection cables are bent too tightly.

Safety Measures:

- Route connection cables according to the specifications of the cable manufacturer.
- Observe the minimum bending radii specified by the manufacturer.
- If no specifications are available, a minimum bending radius of **RB = 10 × cable outer diameter** must be maintained.
- Do not bend cables immediately at cable glands or cable entries.
- Maintain a minimum distance of **10 mm** between the bend and the device housing or entry point.

WARNING!

Damage to cable insulation

If connection cables come into contact with sharp edges or pointed components, this may result in damage to the cable insulation, loss of electrical safety, and a risk of electric shock.

Safety Measures:

- Route connection cables so that they do not come into contact with sharp edges or pointed components.
- Provide appropriate protective measures, such as edge protection, protective tubing, or suitable cable routing.
- Before commissioning, verify that the application is approved for the use of the resistor.
- Check the cable routing for signs of damage.

WARNING!

Risk of injury from hot surfaces

REO resistors can reach housing temperatures >250°C. Contact can **result in burns**.

Safety Measures:

- Only touch the device when it has cooled down or wear appropriate protective equipment.
- Do not route cables along hot housing components, as this may cause temperatures to exceed the manufacturer-specified permissible limits.

WARNING!

Damage caused by mechanical stress on cables

Mechanical damage to the device, loss of function, impairment of the IP protection rating, and reduction of electrical insulation can occur if the supply cables are used to lift or move the device, which may result in electric shock.

Safety Measures:

- Do not use connection cables to lift, carry, or move the device.
- Handle the device only at the designated mounting or transport points.
- Protect cables from mechanical stress and ensure they are routed without tension.

WARNING!

Residual electrical charge

After switching off, residual electrical charges may remain in the device and in the connected voltage circuit. These charges can cause serious injury or damage to equipment.

Check for voltage-free condition

Before touching contacts or live parts of the device or the connected voltage circuit, ensure that:

- the device has been switched off and secured against being switched on again,
- there is no longer any electrical voltage,
- any residual charges have been completely discharged.

The absence of voltage must be checked using suitable and approved measuring methods.

Working on the device

Work may only be performed once it is clearly established that the device and circuit are free of voltage and residual charge, ensuring that no hazards exist for personnel or property.

Hazards in case of non-compliance

Failure to follow these safety measures can result in:

- Electric shock,
- Serious injury or fatal accidents,
- Damage to the device or connected systems.

WARNING!

Pressurized systems

Liquid-cooled resistors are pressurized during operation. Improper work can result in serious injury and property damage.

Personnel Qualification

Work on pressurized systems may only be carried out by trained and qualified personnel.

Selection of components

Hydraulic supply lines, fittings, and connecting elements must be selected by the operator in accordance with applicable legal and safety regulations.

The responsibility for the design, suitability, and compliance of these components lies with the operator.

Ensuring Depressurized Condition

Before starting any work on the resistor or connected hydraulic systems (e.g., installation, removal, maintenance, or replacement of lines and connections), ensure that:

- the resistor has been completely taken out of service,
- the cooling system is pressure-free,
- all supply and discharge lines have been depressurized.

Hazards in case of non-compliance

Failure to follow these safety measures may result in:

- Serious injury caused by escaping media or components,
- Damage to the resistor or connected systems.

WARNING!

Hazard caused by reduced insulation

Storage in condensation or in environments with conductive materials or contamination can impair the insulation resistance of the resistor. This can result in dangerous contact voltages and increased leakage currents. There is a risk of electric shock.

Safety Measures:

- Store REO resistors only in dry, clean, and non-condensing environments.
- Observe the climatic limits specified in the datasheet and in this operating manual.
- Before commissioning, ensure that the device is completely dry, clean, and free from conductive deposits.
- If moisture or contamination is suspected, do not put the device into operation and have it inspected.

CAUTION!

Leaks and functional malfunctions

Retightening or modifying sealing threads on original parts of the resistor is not permitted. This can lead to leaks, functional malfunctions, or damage to the device.

When loosening or assembling threaded connections, especially on cooling connections, the connection options provided by the manufacturer must be secured against unintentional loosening (e.g., by means of a suitable locking device).

Safety measures:

- Do not retighten, modify, or replace sealing threads and factory-fitted original parts.
- Only use the connection points provided by the manufacturer.
- Use counterholds or suitable locking devices when tightening threaded connections.
- It is essential to comply with the manufacturer's specifications for torques and installation.

CAUTION!

Risk of injury from sharp edges

REO resistors are industrial products. Despite design measures to minimize sharp edges and pointed corners, there is a risk of injury when removing the product from its packaging, during assembly, and at the installation site.

Safety measures:

- Special care must therefore be taken when handling the product to avoid cuts or puncture wounds.

NOTE!

Thermal switches/thermal sensors installed on the resistor

Any thermal switches/thermal sensors installed on the resistor are not designed to measure or monitor temperatures at the active part. They are only intended to monitor the resulting temperatures at internal seals and cables.

Safety measures:

- Excessive temperatures measured by thermal sensors or exceeding the switching threshold, factory-installed thermal switches in the seal area, indicate impermissibly high temperatures on the active part as well.
- Disconnect the device from the power supply immediately.
- Monitoring and evaluation of factory-installed thermal switches/thermal sensors are the responsibility of the user/plant 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
- DIN EN 61800
- 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
DIN EN 60204-1 / VDE 0113-1	Safety of machinery — Electrical equipment of machines
DIN EN 60529 / VDE 0470-1	Degrees of protection provided by enclosures (IP Code)
VDI 2230	Systematic calculation of high duty bolted joints
DIN EN ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction
DIN EN 62444	Cable glands for electrical installations
DIN EN 50178	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 IEC 62477-1:2023 + AC:2024
2011/65/EU	Restriction of Hazardous Substances (RoHS)	–

CE

RoHS
COMPLAINT

Changes and Copyright

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

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 $\mathbf{P_D}$ 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 $\mathbf{P_D}$ is lower than the maximum permissible pulse power ($\mathbf{P_{max}}$). 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** ⇒ 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] x100**
- **Overload factor = 100 / ED % (*)**
- **Overload factor = P_{max} / continuous power P_D or P_{max} = continuous power P_D x 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:

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

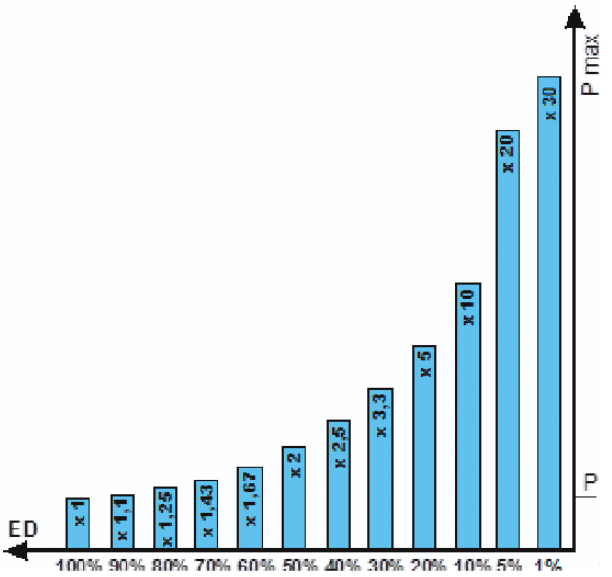
- Duty cycle 50%, overload factor 2:

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

Definitions:

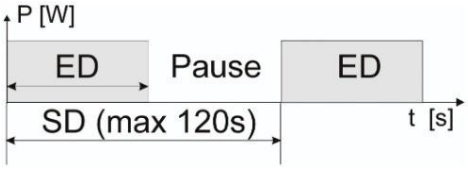
- P_D permissible continuous (average) power over the cycle
- P_{max} maximum permissible pulse power during the ON interval
- The overload factor is calculated from the reciprocal of the duty cycle (e.g., 10 % = factor 10)

3.1.3 Load curves for air-cooled resistors



SD = cycle time max. 120s

ED = duty cycle



Permissible duty cycles for air-cooled REO resistors

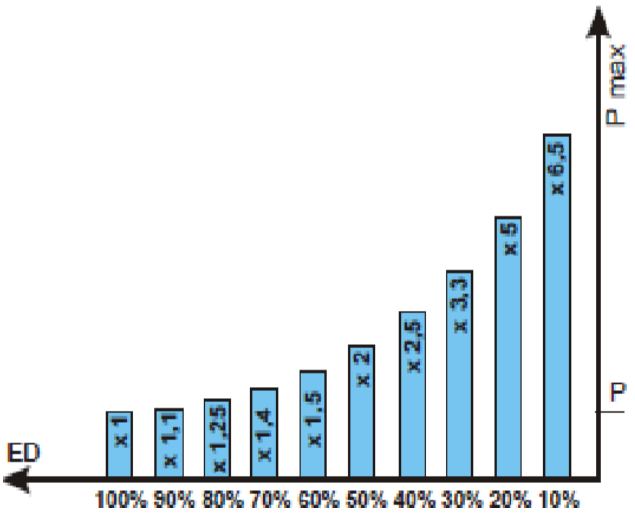
For air-cooled REO resistors, **duty cycles ED** from **1% to 100%** are permissible. The following applies:

- At **1% ED**, the **maximum overload factor K_{OL}** 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**.

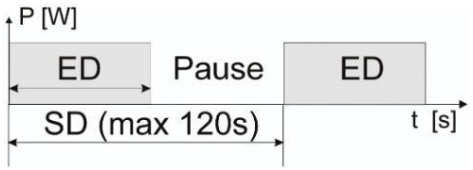
For duty cycles **below 5% ED**, the **overload factor 30** is specified as the maximum permissible value.

3.1.4 Load Diagrams for Water-Cooled Resistors



SD = cycle time max. 120s

ED = duty cycle



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 °C to +70 °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 °C to +70 °C (maximum temperature change: 20 K/h), in accordance with IEC 60068-2-1 / IEC 60068-2-2, unless otherwise specified by REO.
- Relative humidity: up to 85 % 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 Ri ≤ 5 MΩ 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 (Tin) below the ambient temperature (Tu), 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

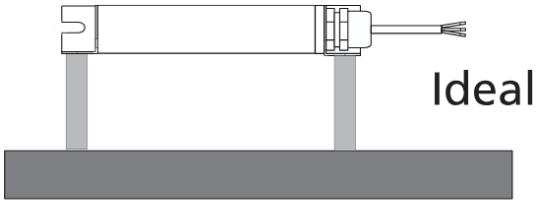
To ensure adequate convection and heat dissipation, the following minimum distances to adjacent components must be observed, unless otherwise specified by REO:

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

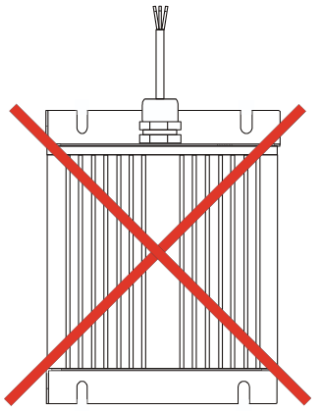
The heat energy generated by the braking resistor must be dissipated unhindered.
Flammable materials or substances must not be installed or stored in the immediate vicinity of the resistor.

5.2.2 Installation position

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

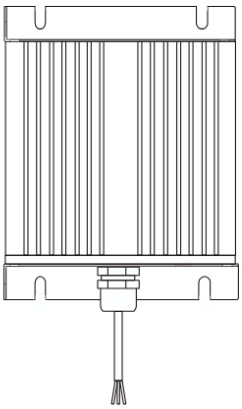


When mounting on a heat-insulating or poorly heat-conducting substrate, the resulting heating of the resistor must be checked due to limited heat dissipation.
The resistor must be mounted in such a way that heat dissipation (e.g., through natural or forced convection) is not impeded.



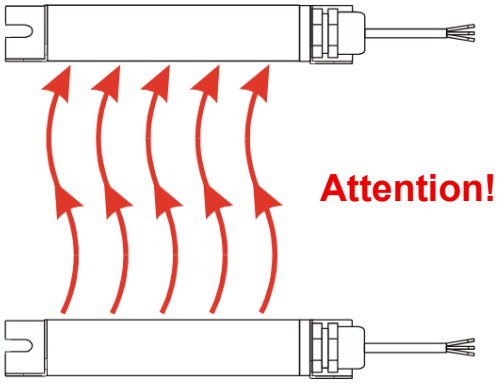
Not allowed
Connection at
the top

Permissible
Connection at
the bottom



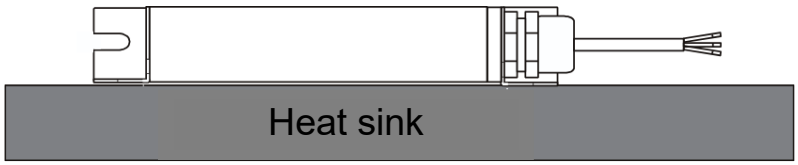
The installation position must correspond to the position specified in the product data sheet or technical specification (e.g., horizontal, vertical, wall-mounted).
For vertical mounting, it is essential to ensure that the connections or terminals are located on the underside of the resistor.
An installation 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 $\mathbf{R_B}$ = 10 × 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 MΩ 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 [mm²]	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
• Smoke or odor development	• Overload • Thermal overload • Short circuit	• Switch off the device immediately • Check the resistor for external damage • Inspect connections and application
• Discoloration of housing or heat sink	• Long-term overload • Insufficient cooling	• Check ambient temperature • Ensure proper cooling conditions and convection
• Noticeable operating noises (e.g., humming, crackling)	• Partial discharges due to moisture • Insulation faults	• Measure insulation resistance • Drying may be necessary
• Measured values outside tolerance	• Aging • Overload • Contact issues	• Measure insulation resistance • Check terminals and connections • Replace device if necessary
• Moisture ingress • condensation	• Incorrect storage or installation environment	• Dry the unit • Check for leaks • Check the ambient climate

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.

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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.

	Name	Signature	Date	Department	Position
Created	C.Wrzesinski		May 7, 2025	KO	Design
Reviewed			May 9, .2025	QM	Quality Management
Approved	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		

Notes:

Notes

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