REO
INDUCTIVE COMPONENTS

TransportationConverter Solutions

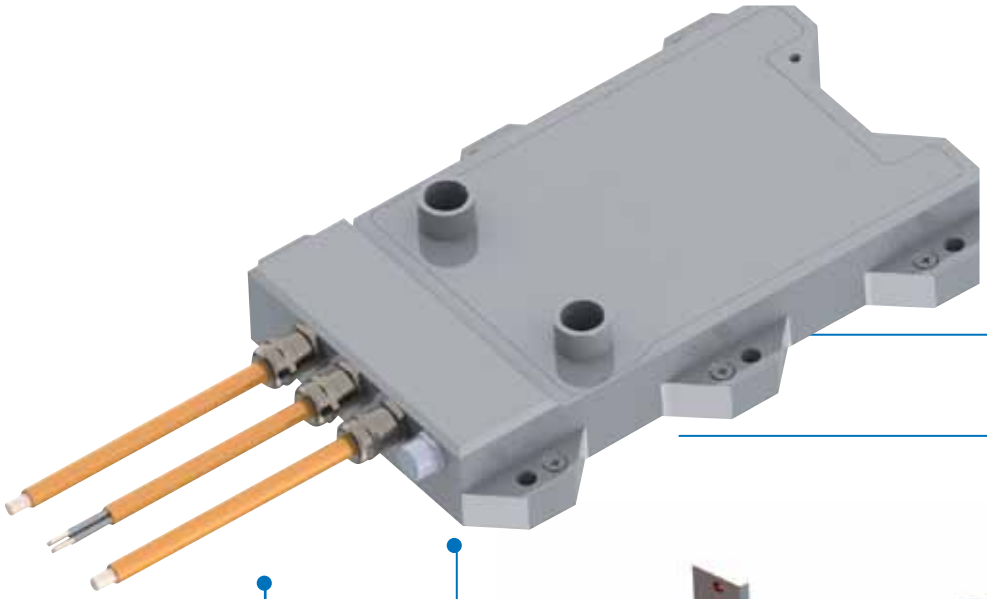
Efficient components from REO

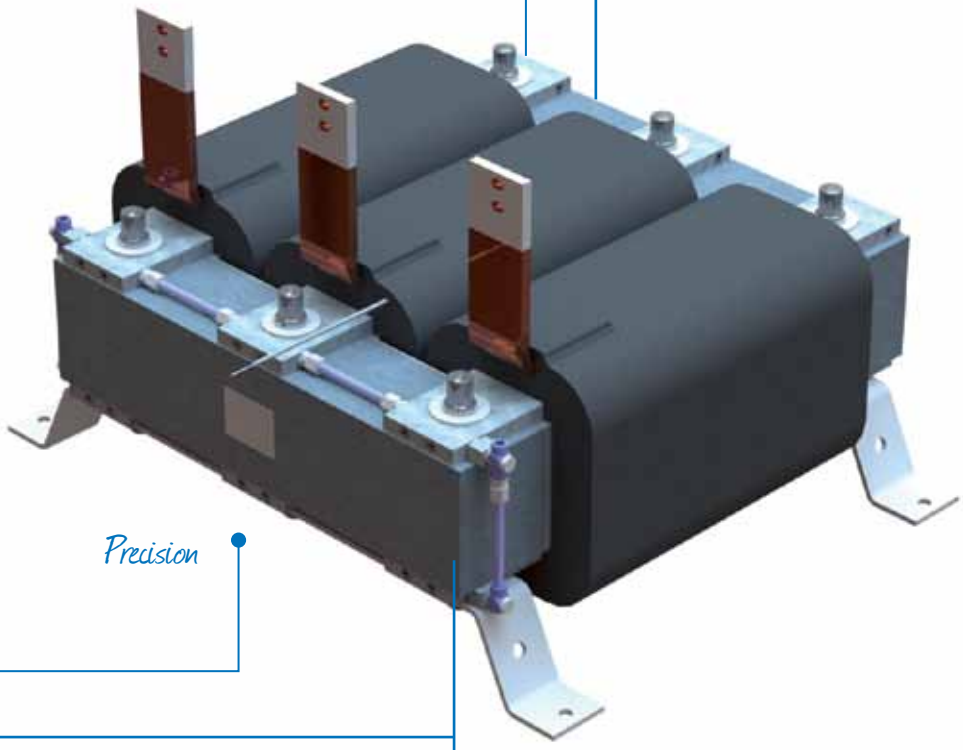
Pure|Power|Perfection

Content:

TransportationConverter Solutions

Efficient components from REO





Robustness

Safety

Precision

Reliability

Rail, High-Speed trains or metroliners, one of the safest means of transport, is advancing into ever more remote corners of the Earth. The railway network is constantly expanding, helping countries come together, and is an engine driving economic growth and prosperity.

REO has set itself the task of contributing to making trains ever safer, today and in the future. With mains filters, inductors and transformers, we ensure that EMC problems are eliminated directly at the source.
The result is that voltage changes, short-circuits and any other problems associated with electricity cannot present a hazard to railway personnel or passengers.
Compliance with international norms, the exploitation of the latest technologies and decades of experience make REO a strong partner.

REO manufactures components for two main areas of railway technology:

A) Auxilary converters:
- **Transformers from 16 2/3 up to 30 kHz**
- **Boost-/Buck converters**
- **EMC-Filter**
- **Sinusoidal filter**
- **Current transformers**
- **Charging resistors from IP 00 - IP 65, available for watercooled systems, too.**

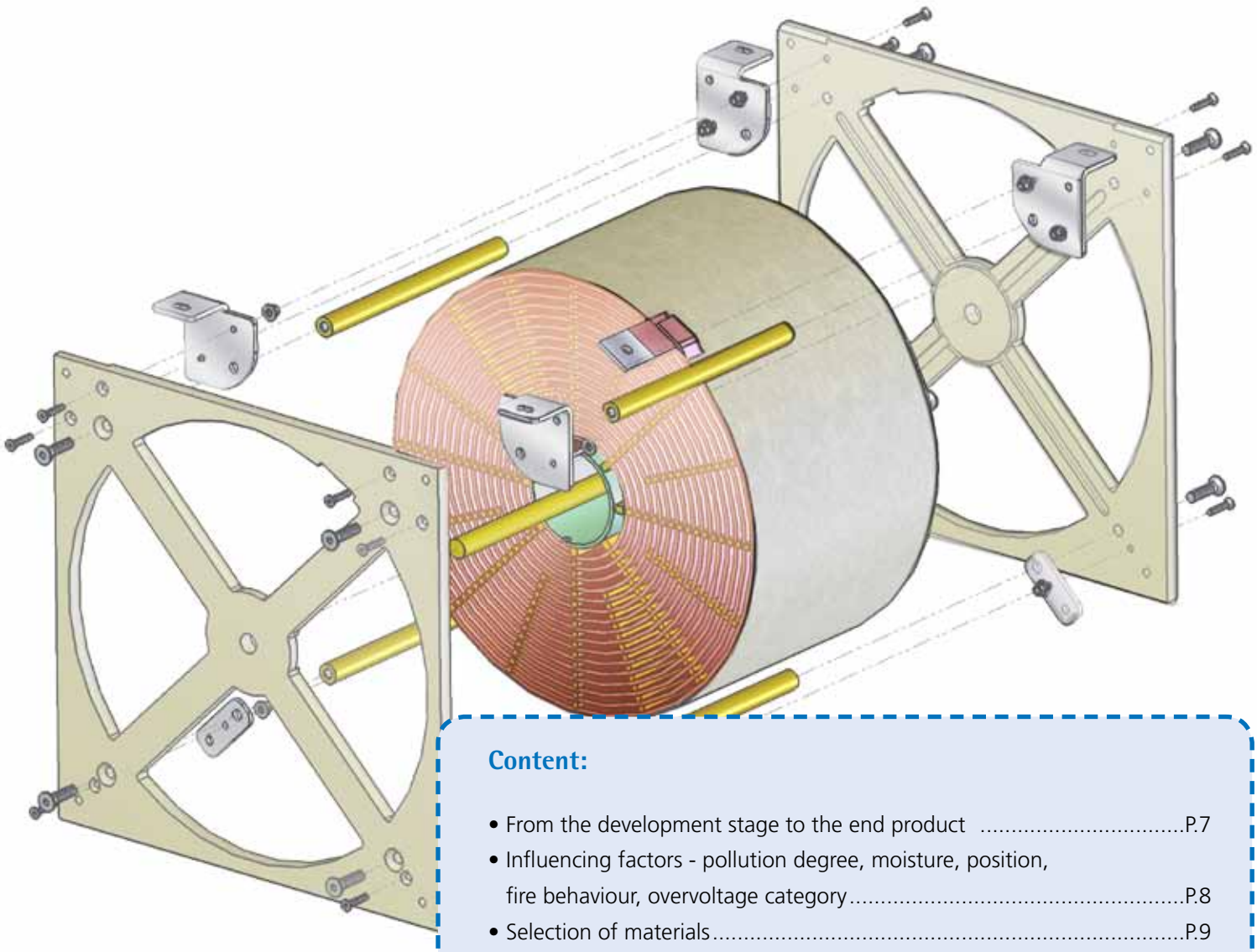
B) Main drive:
- **EMC HV chokes**
- **Leakage transformers**
- **Flow Controls**
- **FE-chokes**
- **Absorption circuit chokes**
- **Onboard power supplies**
- **Damping resistors**
- **Current transformers**
- **Filter chokes**

In its Centre of Competence in Berlin, REO today develops railway engineering components to meet the requirements of worldwide railway organizations and, thanks to partnerships with companies in the USA, China, India and Germany, they are able to be manufactured quickly and efficiently with the highest standards of quality. In conjunction with its worldwide sales network, REO can respond quickly at any time.

With great attention to modern production methods, efficient workflow, close cooperation with universities and the constant further development and improvement of processes, every day REO provides electric railway line builders with products that contribute to the safety, functionality and global growth of rail technology.

With the IRIS certification of the subsidary in Berlin / Hennigsdorf and the ISO certification in China and the U.S., REO demonstrates quality at the highest international standards.

Tailor-made components
right up to the end product



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Key points

All railway technology components - from transformers to line inductors and filters - are developed to meet the standard or special requirements of our clients. No product can go into operation without these fundamentally defined requirements:

- **Safety:**
  Trains have been in use as a means of transport for more than a century. The demands placed on materials become ever greater, in pace with ongoing technical development. To ensure that the safety and comfort of passengers are not impaired, every component used in a train must meet the current norms and standards. Own tests and accredited testing laboratories prove the safety of our components.

- **Weight:**
  Trains are being used ever more rapidly and ever more extensively, insufficiently optimized equipment means stress on the train, fewer persons can be transported and speed and economy is reduced. Intelligent methods in materials selection and FEM-calculation mean that REO components are of particularly low weight.

- **Space requirements:**
  Many components have to be developed in such a way that, together with other products, they fit into the available space.The optimal use of space, and compliance with specified mechanical and electrical requirements, form the basis of our development work.

- **Costs:**
  The optimization of operating costs plays a particularly important role in railway engineering. To remain competitive, train makers have to rationalize costs but without endangering passenger safety in the process.
  With the latest software, simulation and testing techniques, we ensure that the necessary development work is already optimally used in advance.

Tailor-made components

Influencing factors

Besides unit size and weight, there are many other factors that influence a component, such as:

Environmental conditions
If a component is used on the outside of the train, the degree of pollution it is exposed to is an important factor. Dirt can get into components, impairing their functionality and shortening their useful lifetime. REO components can be designed for a pollution degree of up to PD4 and a temperature of -50°C or worse.
The clearance and creepage distances are realized according to DIN EN 50124-1.

Moisture
Wetness and moisture, in conjunction with typical railway contamination and high temperatures, can impair function. If moisture gets into electrical windings or cabling systems, short-circuits and thermal overloading may occur.
With the aid of a special coating and various sealing techniques, REO products achieve a high protection class and are particularly resistant to dirt, moisture and other environmental effects.

Acoustics
Especially in the field of railway technology acoustics plays a growing role.
REO develops and uses technologies, processes and materials that allow to meet and exceed the acoustic requirements and standards (DIN EN 60076-10).
Thus, even levels below 85dB sound pressure level can be realized. As standard, the airborne sound is measured, and if desired a structure-borne noise can be done, too.

Position of equipment
The position of railway components plays an equally important role in their design calculation. Factors like weight management and train construction are important issues.

Preventive fire safety
The behaviour of materials in a fire plays a crucial role in passenger safety.
All materials used are prepared in compliance with the applicable norms and are tested by accredited test laboratories for their behaviour when subject to a fire and its side effects.
The test reports and the corresponding documentation are made available to clients.
Standards such as EN 45545, DIN 5510 and NFF 16101 are self-evident.

Protection grades:
IP00 – IP65

Pollution level:
PD1 – PD4

Fire protection standards:
EN 45545, DIN 5510,
NF F 16-101 / NF F 16-102

Special silicone coating

For a sinusoidal current, and improved acoustics

Choke, developed according to customer specifications and used under the floor.

Selection of materials

The optimization of unit size and weight is dependent on the selection of the core materials and winding materials. REO has many years of experience in the manufacture of inductors and transformers and can select the optimal materials for a specific project. Direct and focussed analysis of the required material properties helps minimize the costs.

The following options are available:

- aluminium
- copper
- iron
- amorphous and nanocrystalline materials
- carbon fibre-reinforced plastics and insulating materials

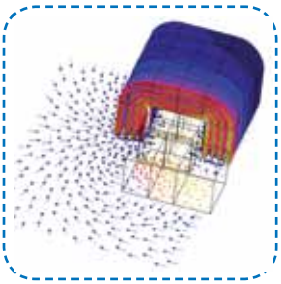
In addition, the selected product design has a substantial influence on mechanical and electrical characteristics:

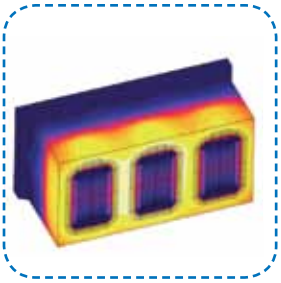
- cylindrical air-core inductors
- iron-core inductors
- toroidal air-core inductors

The type of cooling should also be decided in advance. REO offers various types of cooling:

- AN, AF air cooling
- water cooling

Tailor-made components





Tests/analytical techniques

Tests/analytical techniques
After electrical design calculation, and during mechanical design, the components undergo various tests with the assistance of simulation tools and analytical tools before they go into prototyping.

Such simulation techniques as FEM analysis based on solid 3D models give information about physical magnitudes. These are further analysed as a consequence of design calculation, and product optimization measures are undertaken, if required.

These various simulation techniques permit working with the optimization of time and cost, since the findings accumulated in the simulation process can subsequently be implemented in the prototyping. This
procedure enables those problems that may crop

Here is an overview of some of the main types of analysis:

3D magnetic-field simulation

Comprehensive electromagnetic and thermal calculations can be performed based on the three-dimensional finite-element method (3D FEM).

FEM thermal simulation

Besides the electromagnetic three-dimensional field calculation, thermal design calculation based on FEM is also of great significance for REO, because it permits a look inside an actual product and subsequently supplies important findings here about local hot spots that could endanger the expected useful lifetime of a product in the medium term.

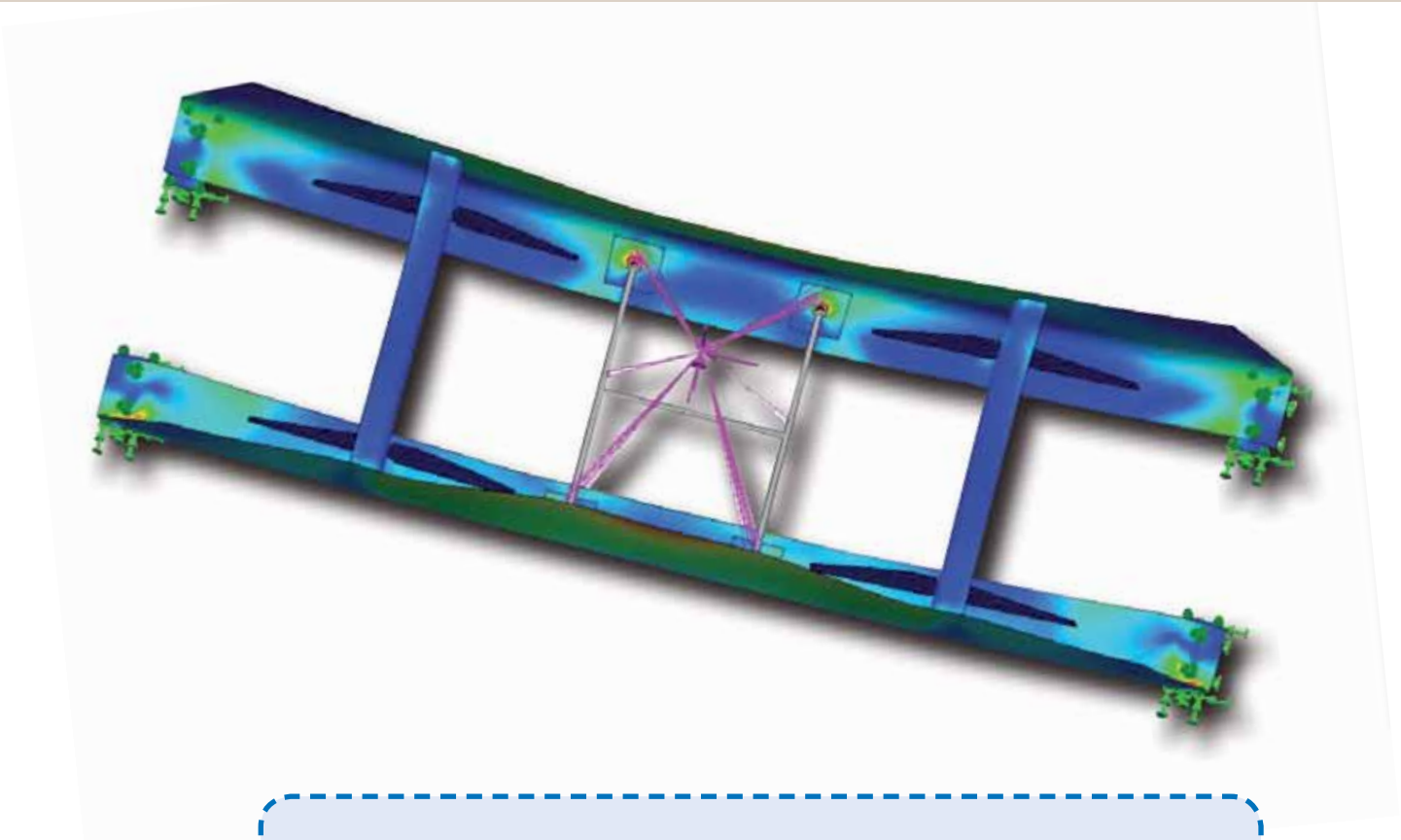
This makes it possible to design products thermally in the development phase before production begins. This ensures that the finished product has a long lifespan.

FEM analysis of structural mechanics

Physical factors influencing the component are simulated using the FEM analysis, based on 3D CAD model designed using SolidWorks.

This enables the following calculations to be made:

- static and dynamic linear and nonlinear stress analysis
- frequency analysis
- analysis of lifetime
- design calculation of screw strength
- welding seam calculation



Norms and standards used by REO:

- IRIS certified (Rev 02, V 2.2)
- EN 15085 CL1
- DIN EN 60310/VDE 0115 Part 420/IEC 60310: Railway applications - Traction transformers and inductors on board rolling stock
- EN 12663-1: Railway applications - structural requirements of railway vehicle bodies
- EN 15085-1 bis -5: Welding of railway vehicles and components
- IEC 61373: Rolling stock equipment – Shock and vibration tests.
- EN 50125-1: Railway applications – environmental conditions for equipment
- DIN EN 60076-10: Determination of the noise level
- EN 50124 Railway applications - insulation coordination (basic requirements -clearances and creepage distances for all electrical and electronic equipment)
- IEC 60085: Electrical insulation - thermal evaluation and designation
- DIN EN 61378 and 60076: Convertor transformers and power transformers
- Underwriters Laboratories Inc. (UL) certification for REO systems of insulating materials in thermal classes F (155°C) and H (180°C) in accordance with the UL1446 standard.
- UL and TÜV certification for REO EMC filters, inductors and braking resistors
- Fire protection standard: EN 45545, DIN 5510, NF F 16-101 / NF F 16-102, BS 6853

Tailor-made components

Construction of prototypes

After the analysis and testing phase is satisfactorily concluded, the product is manufactured as a sample using the results derived from the FEM analysis. This is a complete in-house prototype. All prototypes can be completely manufactured in the production facilities in Hennigsdorf and Kyritz utilizing in-house metal work, CNC machining centre, insulating materials workshop and welding bays.

Type testing

At REO, every railway component undergoes complete type testing in accordance with EN 60310. This includes the complete verification and validation of the design, partially by external accredited companies.
Testing in accordance with EN 60310 includes the following tests, among others:

- acoustics measurement
- temperature test
- partial discharge measurement
- high potential test and high-current test
- shock and vibration testing (external)
- salt and mist testing (external)
- EMC testing

Components submitted by a client, such as frequency converters etc., can be integrated with our specially fitted testing stations with their modular units.

Safety has absolute priority in rail travel: faults in this exacting field of engineering can have catastrophic consequences. So railways are subject to special additional norms dealing with mechanical stability, shock ad vibration, and resistance to EMC.

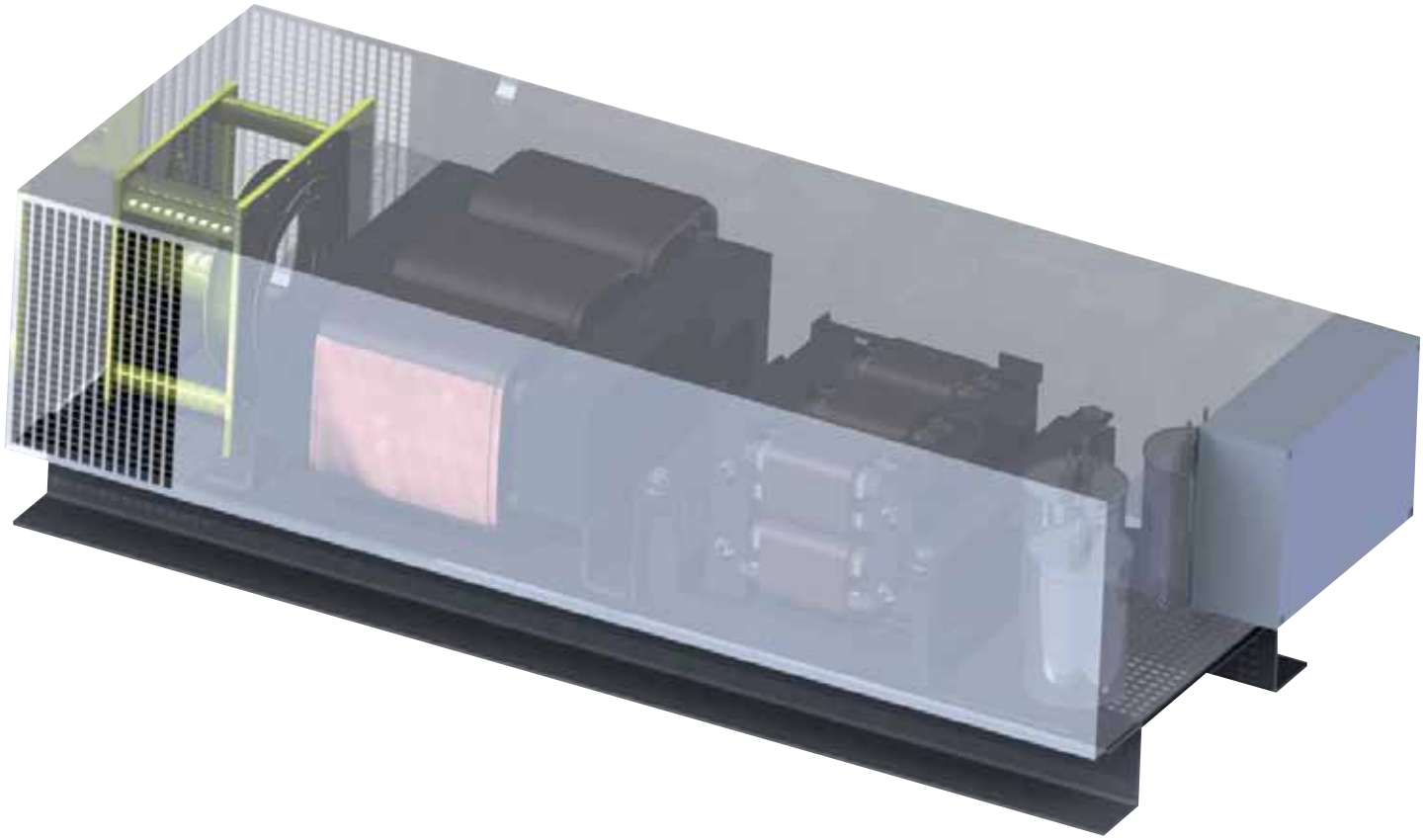
Millions of people use trains as their means of transport every day. For this reason, countless international standards and norms are applicable to railways to ensure passengers safety.
Our engineers develop reliable railway components based on these norms and those demanded by clients.

The different stages:
Construction phase, 3-D model, final product.

Tests/Analyses technologies ····· Full prototype ····· Type test ····· Final product

Our product range

Components for auxiliary converter



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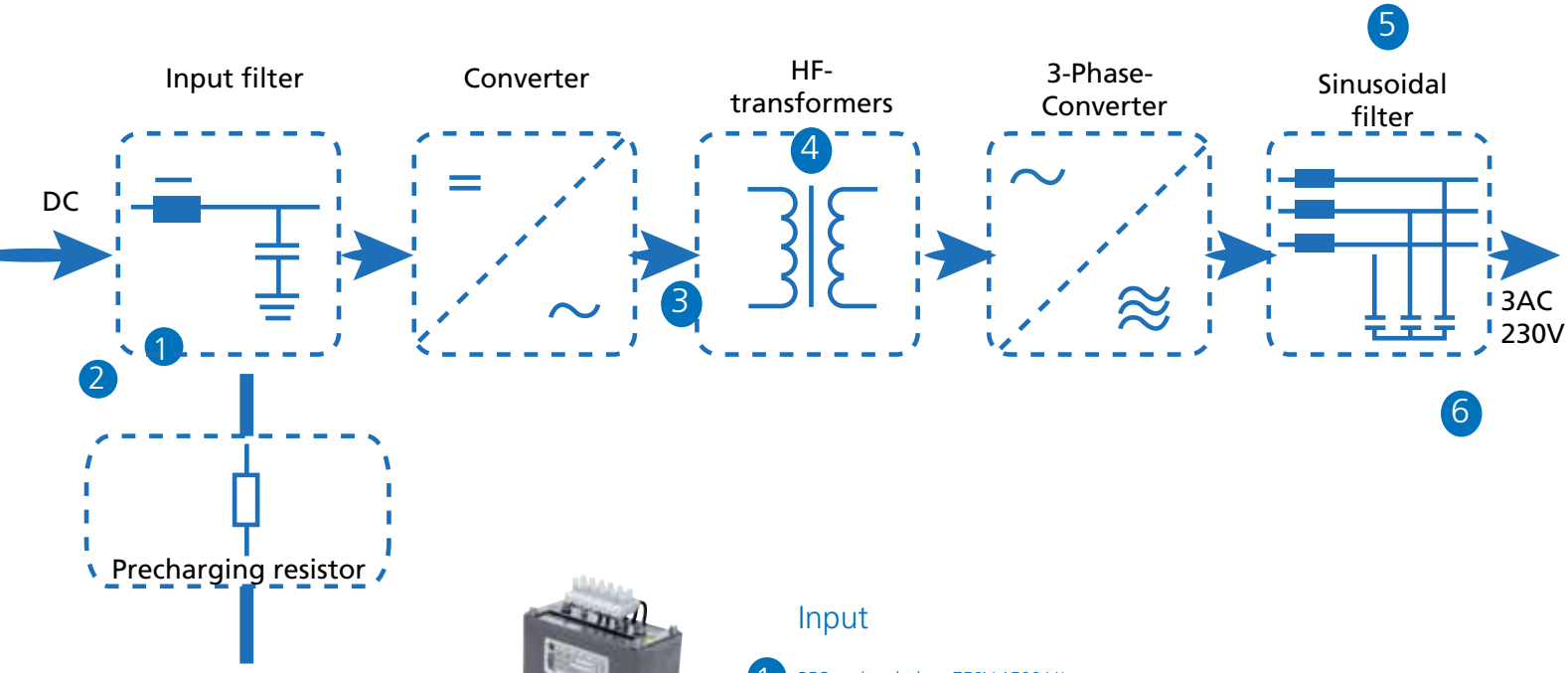
Components for auxiliary converter

Electric railways have an extraordinary energy demand, e.g. for heating, air conditioning, lighting or
cooking in the bistro car. All of these peripheral applications normally require a supply that is different from the available electricity source. In addition to providing optimum power to these facilities there is also an important requirement to ensure electromagnetic compatibility for the protection of passengers.
These auxiliary converters must meet the tough requirements of railway technology: shock and vibration resistance, high protection levels and a long life are just a few examples of these demands

REO develops and manufactures components for this purpose, often available as standard products but also providing fast turnaround of special designs - for every application the right solution!

Our product range

Multitude of applications

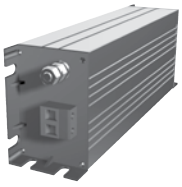


Input

1 REO mains chokes 750V-1500 V*

– in cast design for ingress protection up to IP65; Used for reducing commutation losses and harmonics; very robust and good heat transfer

or



REO EMC-Filter*

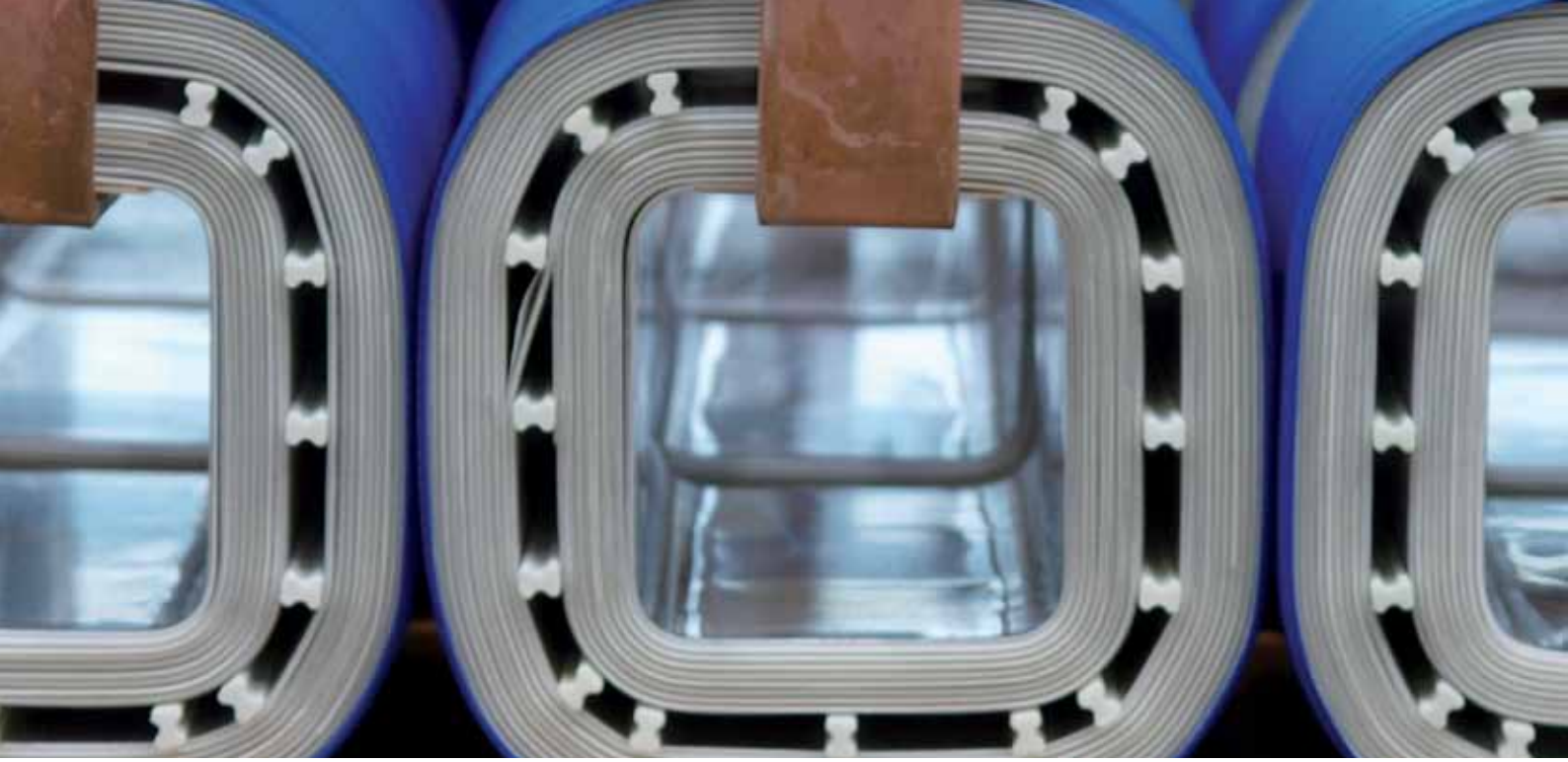
with high attenuation (up to 100 dB from simple to broad spectra) in a practical profile housing for variable installation and with low heating guaranteed

2 REO Charging resistors (up to 3kW)*

– high power density, wide variety of connection options and possible combinations of several resistors in one profile (type of protection up to IP67)

Many REO components are also available in a liquid-cooled design (direct cooling).
Alternatively, a water-cooled sub-element can be used (indirect cooling), which is combined with the REO-component.

In this simple way, a liquid-cooled system can be easily achieved with all the benefits of a modern water cooling.
For more information on water cooling in rail technology, see page 26



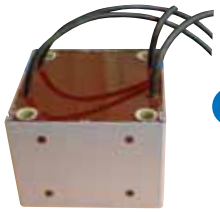
DC-link

3 REO Boost/Buck converter

The choke is used in applications where DC voltages are converted into another (higher or lower) DC voltage in a vehicle power supply and is operated at a voltage of 500 V .. 1100.

Chokes are manufactured with copper windings and amorphous core.

or



4 REO HF-Transformer

The HF transformer is used for example at a voltage supply as an isolating transformer. A safe separation and low partial discharge voltages are characteristic.

Output

5 REO Sinusoidal filter (690 V / 1200 A)*

– for giving sinusoidal form to current and voltage. For example, used in air conditioning systems against noise (protection up to IP65)

or

REO dv/dt-filter (690 V / to 150 A)*

–for limiting the voltage rise at the output from the converter with high inductance, low total losses and minimal leakage field (type of protection up to IP65)

or

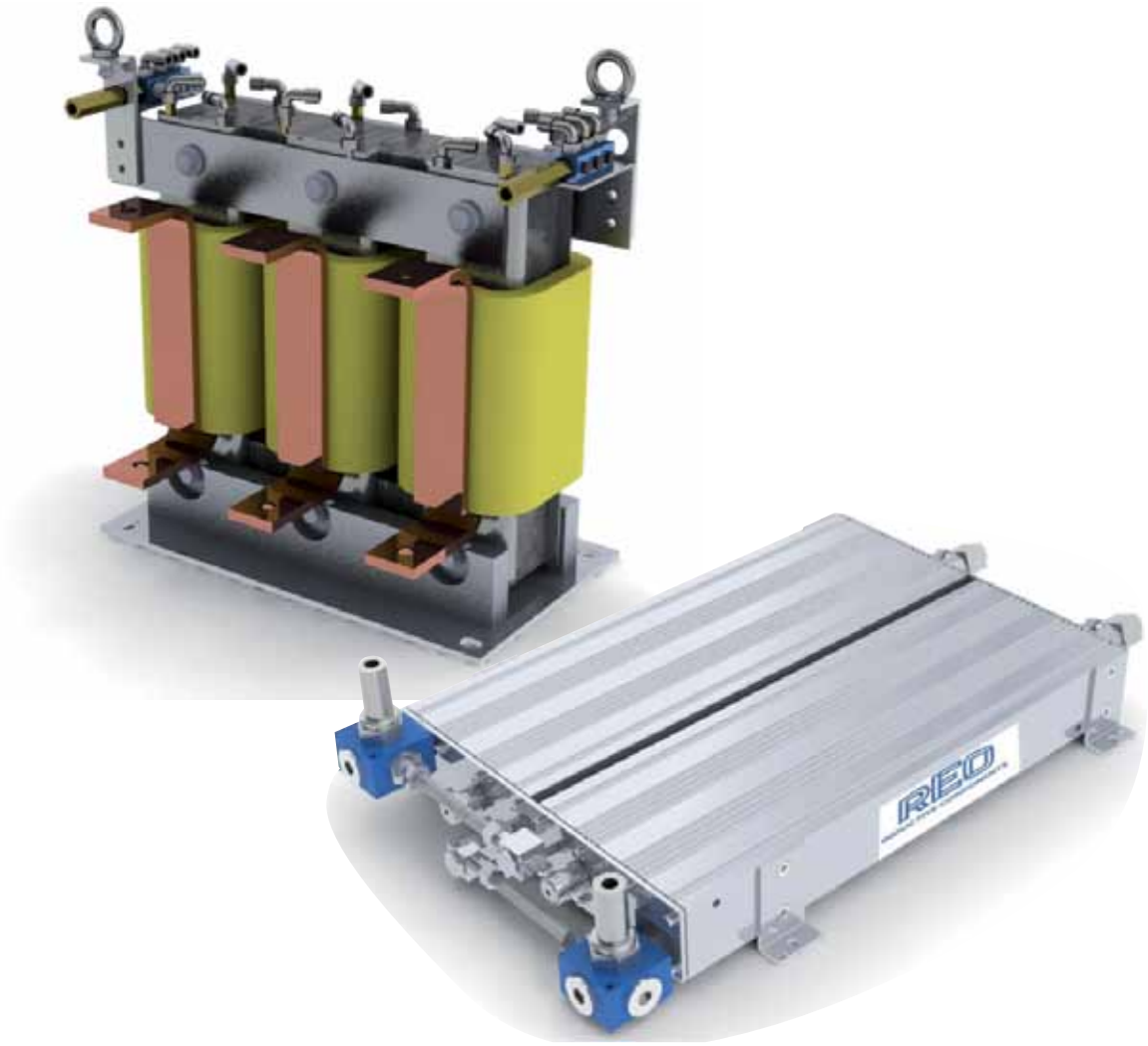
6 REO Current transformers (0 - 1000 A)*

– in suitable design for AC/DC measurements up to 150 kHz in railway applications, distinguished by short response times and excellent linearity.

*higher performances on request

Our product range for auxiliary converter

Inductive and resistive components for railway engineering



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Excellent components for safety in railway technology

With the use of modern inverter engineering in electric trains, techniques such as pulse-width modulation are used, generating voltage pulses with a short rise-time to achieve high power ratings. However this technique has several issues which can cause undesirable effects, such as the loss of motor power. Some of these problems are:

- EMC issues
- Harmonic distortion
- dv/dt problems
- Voltage surges
- Short-circuit currents
- Interference currents

In addition to these phenomena there is also the need to absorb excessive energy such as switch-on or transient current surges, caused by starting-up and slowing-down a train, to provide the most efficient motor performance.

Solutions from REO

Since most of these problems occur simultaneously, it is most important for REO to a take a holistic view of the system. REO provides closely-matching solutions for inductive and resistive components used around the train's drive motor system and for auxiliary applications; from a single source – this ensures that the most efficient design for the application and an

overall awareness during the early stages of the development phase, are available.
As a leading supplier of complete inductive and resistive solutions REO offers a wide range of components for the enhanced performance of railway drives and train electrical equipment.

- AC- chokes
- Damping resistors
- Filter resistors
- Short-circuit Resistors
- Grounding resistors
- Interference chokes
- Inverter transformers
- Chopper-Chokes
- Absorption circuit chokes
- AC-Transformers
- Power transformers
- Auxilary transformers
- Combinations
- Braking resistors
- Assemblies of special components for energy regeneration

REO demonstrates a particular strength acquired through long experience with inductors. The broad base of completed projects in railway technology, guarantees a good result, particularly for customized solutions.

Our product range for auxiliary converter

Inductive and resistive components for railway engineering

Customer-specific components

Besides the standard components for use in the converter, REO offers customer-specific products - as individual components or as a complete solution in a container.

The overriding criteria in railway engineering are availability for operation and passenger safety. Here, REO offers customized solutions that we develop step by step in close cooperation with our client.

This guarantees that REO line inductors and transformers are optimally suited to your application. Our development methods emphasize maximum useful lifetime, cost/benefit optimization and safety.

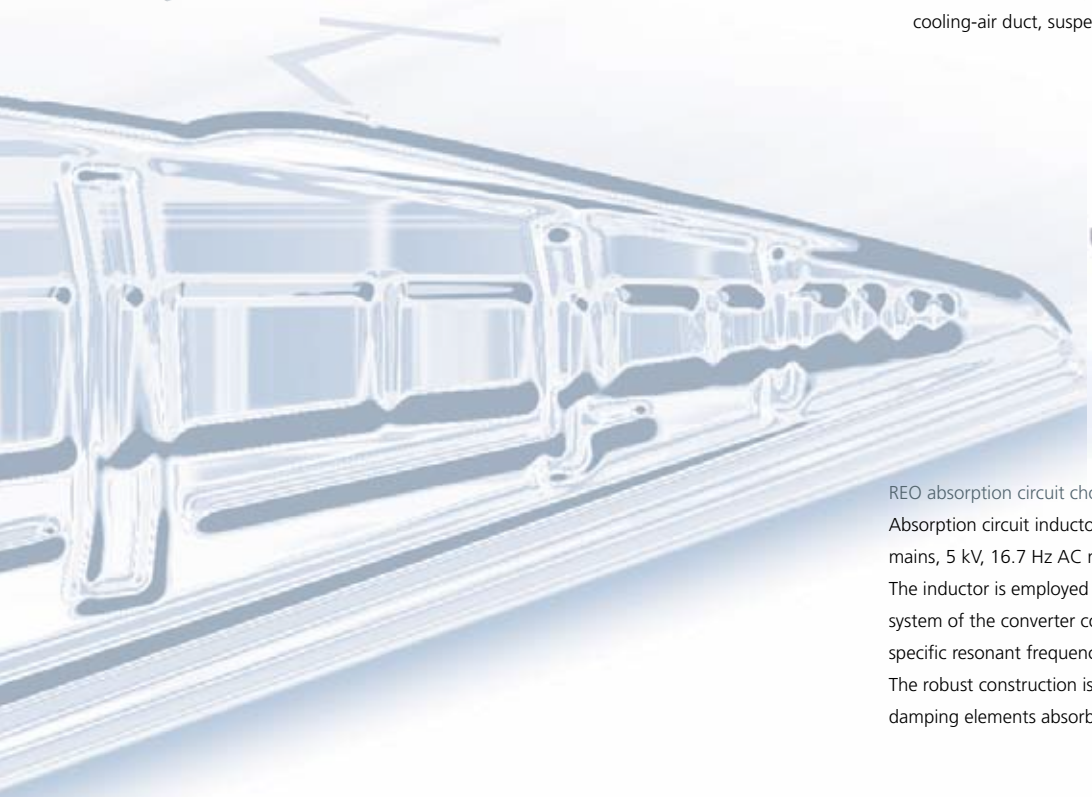
REO three-phase transformer
– is completely impregnated and mounted in a robust casing to protect of the winding against external influencing factors. This transformer is used for supplying voltage to kitchen appliances in a high-speed train.

REO damping resistor
The NTT R 159 resistor is used as a damping resistor in series with a filter capacitor in a traction power converter on the 3-kV DC mains.

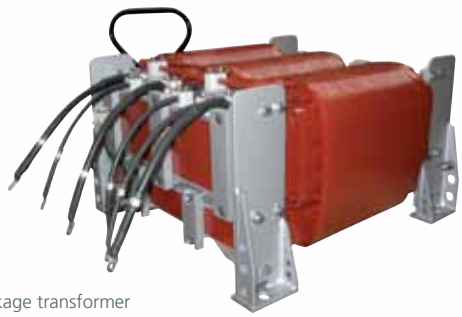
REO three-phase converter transformer
– is employed in auxiliary converters for the galvanic separation of link DC voltage up to 2000 V DC. Special impregnation serves to protect the transformer against external influencing factors.

REO air core line chokes
– is designed for use in electric railways operated on DC networks.
The special configuration of the inductor permits full functionality even under extreme conditions.

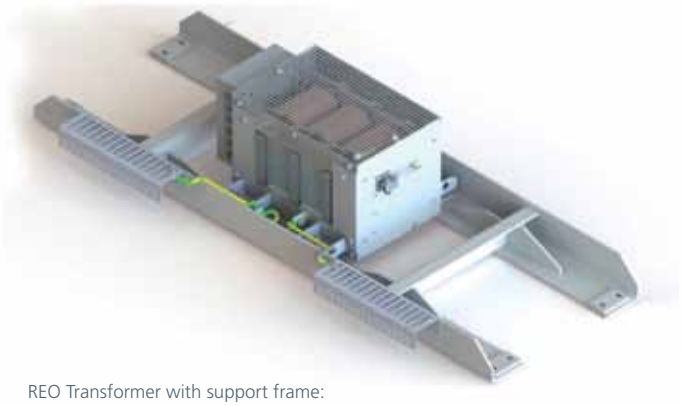
REO DC filter choke
– as a complete, ready-to-use unit consisting of choke, cooling-air duct, suspension and connections.



REO absorption circuit choke:
Absorption circuit inductor for a multi-system vehicle (25 kV, 50 Hz AC mains, 5 kV, 16.7 Hz AC mains, 3 kV DC mains, 1.5 kV DC mains)
The inductor is employed in combination with a capacitor in the cooling system of the converter container to create a resonant circuit for a specific resonant frequency.
The robust construction is designed for secure assembly, with special damping elements absorbing vibrations.



REO REO Leakage transformer
The REO leakage transformer ensures harmonized current and voltage outputs, filtering harmonics, and limiting the ripple current. With the spatial separation of the primary and secondary windings and the resulting intentional increase in the magnetic leakage field, the REO leakage transformer achieves a loose magnetic coupling.



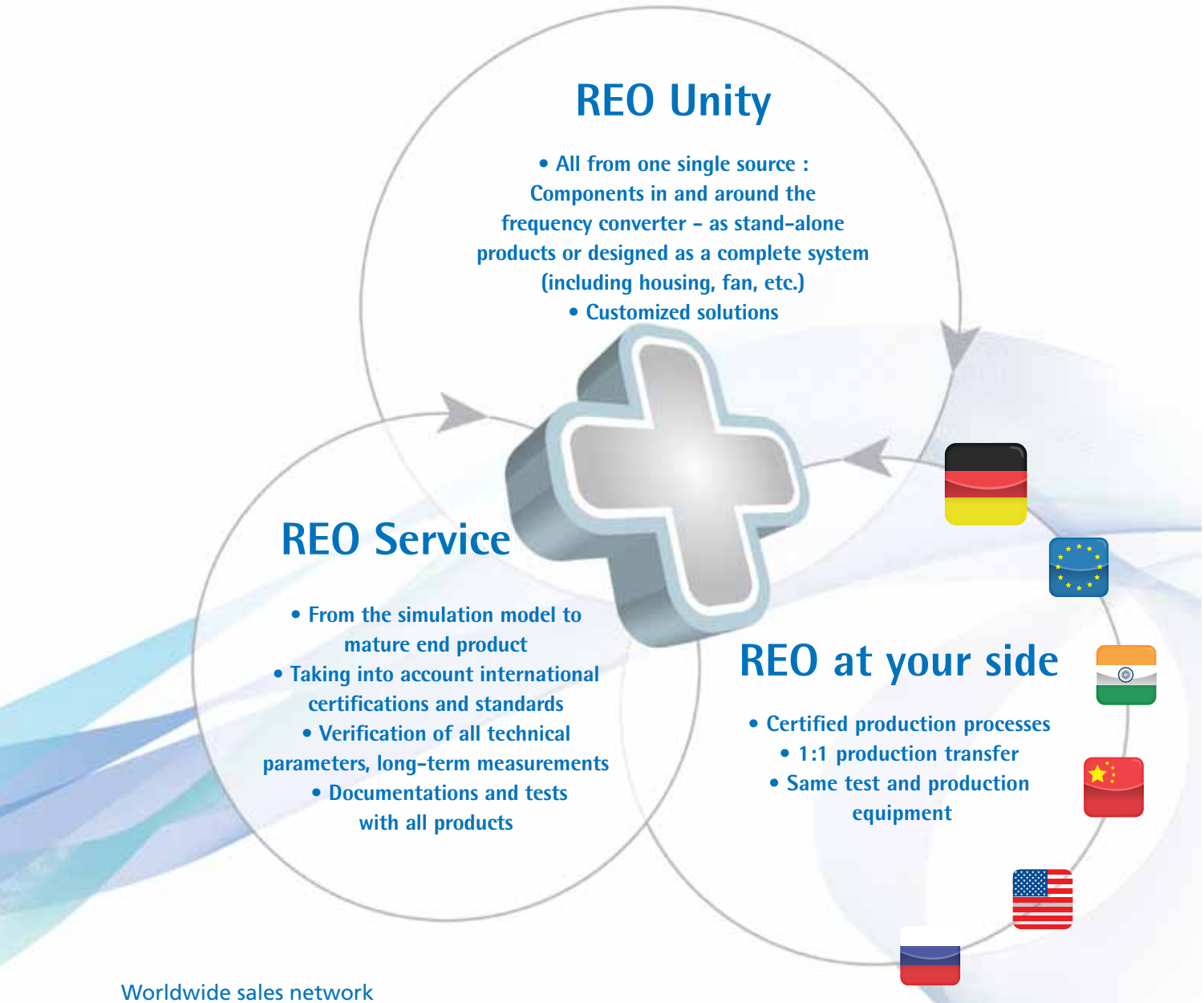
REO Transformer with support frame:
Arrangement for mounting on the vehicle roof or under the floor to supply various kitchen appliances.

REOplus

Global quality and local service

- REO Unity
- REO at your side
- REO Service

Inhalt:



Worldwide sales network

With a worldwide sales network and a very comprehensive product portfolio, REO can react rapidly to your wishes anywhere in the world - no matter what language you speak.
Besides our wide selection of standard products, we can of course offer you tailor-made solutions, developed specially to meet your wishes.

Our production facilities in China, India and the USA are equipped in exactly the same way as those in Germany, and can make every product 1:1.

Even after the 1000th production run, a REO product always has the same quality, everywhere in the world.
Using the same software, with development and design in Germany and intensive communications between our locations, we ensure that REO products are always up to the latest state of the art.

The REO group is made up of companies with many years of experience as manufacturers of inductive windings, located all around the world. Based in Germany and with its technical engineering know-how housed in its Centre of Competence in Berlin, the REO Group provides its railway engineering clients with all the advantages of a company producing locally.

REOplus

Production locations and field sales offices

With production locations in the USA, China, India and Germany, REO offers decisive advantages worldwide.

Technology: REO is a reliable source of mature technology for the world. With development focused at the Centre of Competence in Berlin, manufacturing meets the same quality standards at every production location. Production monitors, standardized production equipment and the use of the same software worldwide ensure 1:1 manufacture everywhere in the world.

Finance: As a group of companies operating worldwide, REO has a strong financial background that makes long-term cooperation secure.

Cost-efficiency: REO benefits from local site conditions, which enable it to function substantially more efficiently and flexibly as regards the pricing.

Speed: Local production eliminates long transportation routes. So REO can also meet short-term delivery deadlines.

Service: An engineer who can solve a client's problems in the local language and on site, is much more efficient than one who operates across geographical and cultural divides. REO's branches worldwide enable it to do justice to this requirement.

IRIS-ZERTIFIZIERT
EN 15085 CL 1
ZERTIFIZIERT

The main focus at the „Centre of Competence" in Berlin is on development and on sales in the domain of transportation converter solutions. Development work is done for international manufacturing in America, China, India and Germany (Hennigsdorf). The Centre of Competence is affiliated to a strategic global purchasing department for the area of railway engineering.

DIN EN ISO
9001:2008

REO SHANGHAI INDUCTIVE COMPONENTS CO., LTD.
Our partner for the Chinese market – specializes in the production of railway components, in close cooperation with the Centre of Competence in Berlin.
Components for railway engineering (chokes, filters, transformers and components in and around the frequency converter) for use in drive technology and in the domain of renewable energy sources are produced in China A 1577-m2 production hall and identical production and testing equipment ensure excellent quality.

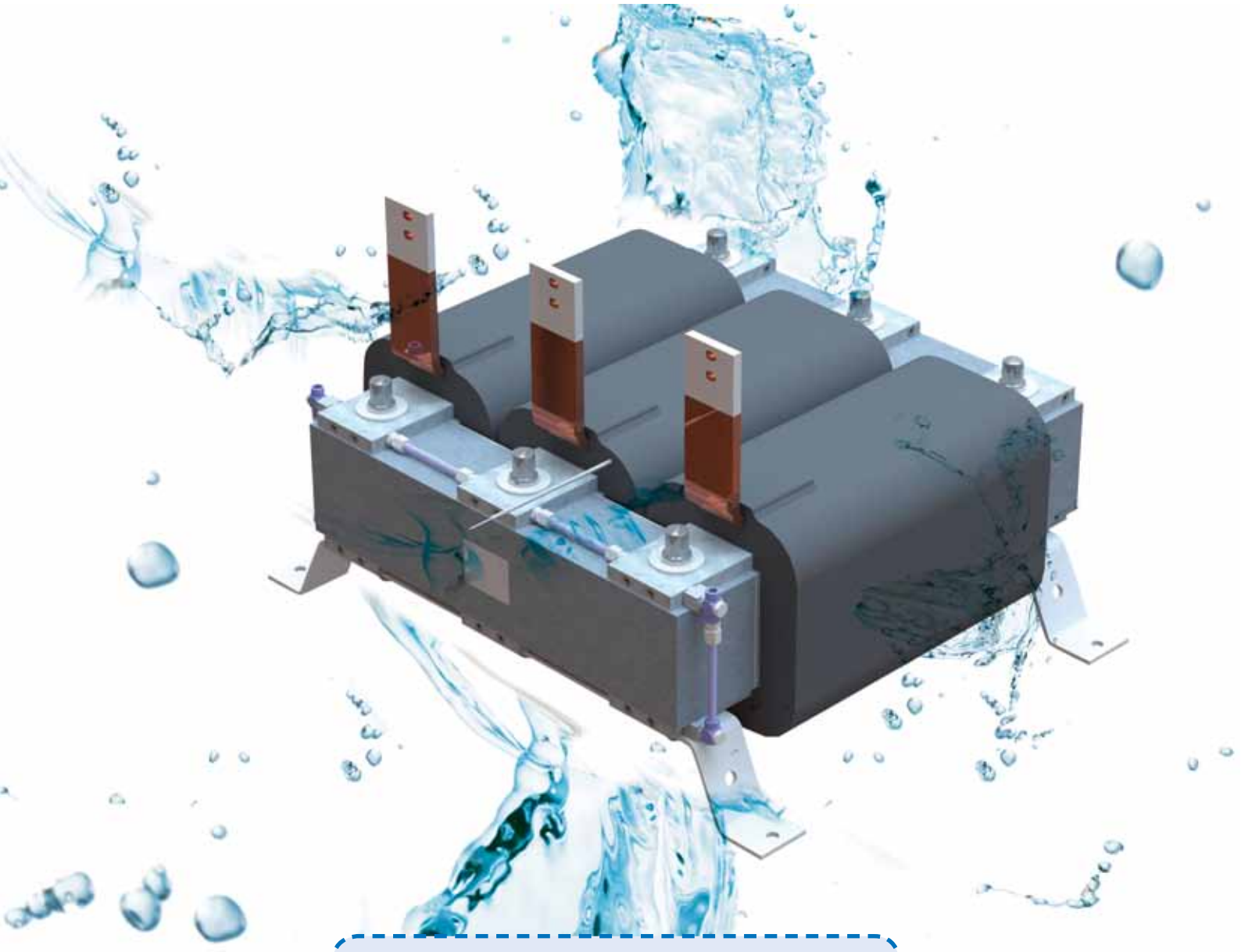
REO-GPD Inductive Components PVT. LTD. is a joint venture between REO and GUJARAT PLUG-IN DEVICES PVT. LTD.GUJARAT PLUG-IN DEVICES has been operating on the
Indian market since 1985 and is an active producer of windings there.

DIN EN ISO
9001:2008

REO USA, inc: REO has been represented by a field sales office in the USA since 2000; We invested in a 2118-m² production hall in 2010.
REO USA has also been ISO-certified since July 2011.

Solutions of REO

Watercooled components in railway technology



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Watercooling

Using water-cooled systems, one can convert significantly higher capacities using the same surface area - from which increased cooling efficiency arises.

REO has long since recognized the trend towards water cooling and has operated developments in the water cooling area for inductive and resistive components. This has enabled REO to build up a comprehensive know-how and a wide spectrum of water-cooled products.

Water cooling is an excellent solution, especially for the use of inductive and resistive components, as temperature behavior plays a major role here. Water cooling enables the temperature of the components to be kept at an optimum level in a unique way, as high power losses are directly transported out of application via the cooling lines. This ensures a longer
lifetime for the components as well as increased performance.

Water cooling is a technique that pays off

Water cooling is a technique that pays off
Constructing this kind of system may be initially connected with higher costs than with regular forced air cooling, however, these investments pay off in the end. Various benefits can be achieved by water cooling:

- High efficiency and low noise levels
- Minimization of construction sizes up to 80% with resistors
- Effective cooling with high ambient temperatures
- Very low excess surface temperature
- Increase of lifetime with normal operation
- Constant, high performance, as temperature is directly dissipated
- Only cooling type during which the temperature may fall below the ambient temperature
- Very well suited for industrial applications in which components with low surface temperatures are required (wood and textile industries or in explosion-protected environments, wind turbines)

Watercooled chokes

A specialty of REO

The chokes are available in protective types IP00 to IP65. REO- can realize various types of water cooling for these components. This means the targeted discharge of losses via the cooling circuit - the losses are not discharged into the environment. By using water cooling, the temperatures in the components can be greatly reduced - this means less stress on the insulation materials and a longer lifetime.

Series CNW MC - for smaller components

- Reactor cast on a metal plate, with integrated cooling channels. This component enables targeted and optimized cooling for smaller power levels and is characterized by its simple integration into existing cooling systems
- Available in 4 versions (IP00, IP20, IP20+EMV and IP 64)
- Current 3-70A

Series CNW MD - for medium to larger power levels

- Choke in an open design, for which the cooling profile is integrated into the winding. With this technology, the heat can be directly tied to its source and can be removed easily.
- Completely encapsulated chokes, for which „water pockets“,are connected to a water cooling system. These are constructed within the windings and encapsulating compounds. This technology unites the advantages of encapsulation technology to achieve a high protective class and the effective heat dissipation at its source.

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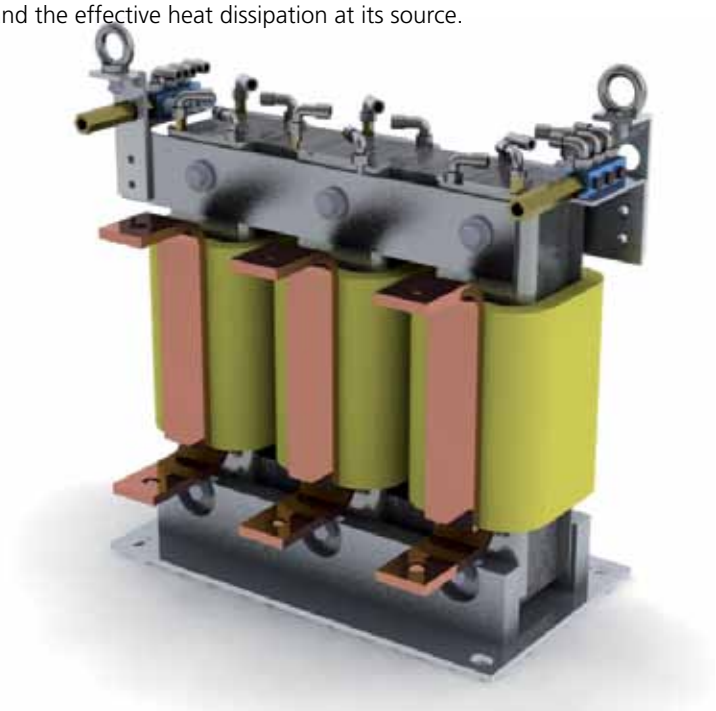
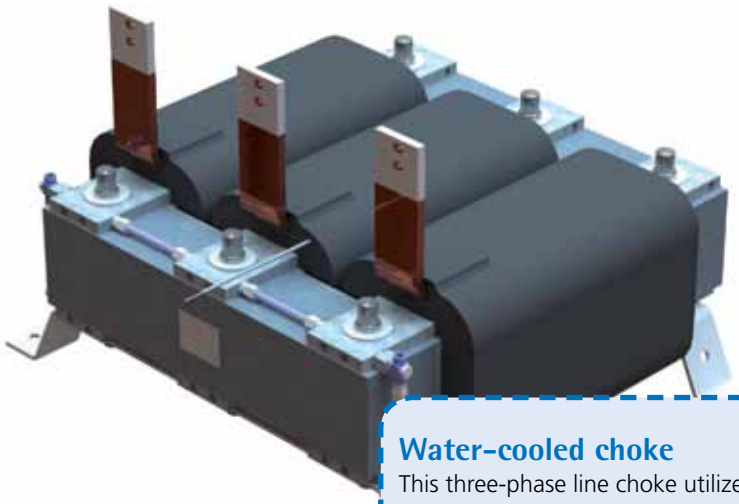
Open design:

- Type: CNW MD
- Current: 100-1200 A
- Protection: IP 00 ...IP 40
- Inductance: 5-147 mH



Encapsulated version with water-pockets

- Type: CNW MD
- Current: 100-3000 A
- Protection: IP 00 ...IP 65
- Inductance: 5-200 mH

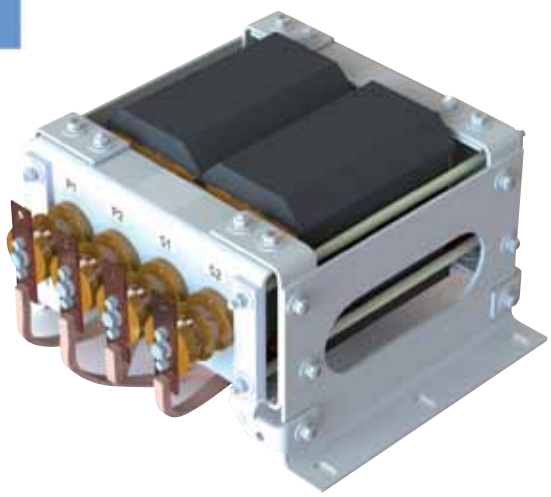


Water-cooled choke

This three-phase line choke utilizes a single casting of the coils and provides very good inductance and minimal physical dimensions.

Advantages of water-cooled chokes

- Max. temperature CNW 953/180 air-cooled: 205°C
- Max. temperature CNW D 953/180 water-cooled: 120°C
- Max. temperature CNW MD 953/180 water-cooled and poured: 68°C



The advantages of the water cooling method can be clearly seen based on the measurements. All 3 variants were tested with the same load; when doing so, the open water-cooled reactor had a temperature advantage of 52 K.
In the CNW MD version, the temperature in the reactor could even be lowered by 137 K. This advantage was achieved due to special encapsulation techniques and a special REO construction. In addition, the behavior at different inlet temperatures was researched to test the behavior at different operating conditions.

Water cooled resistors

Ideal for railway technology

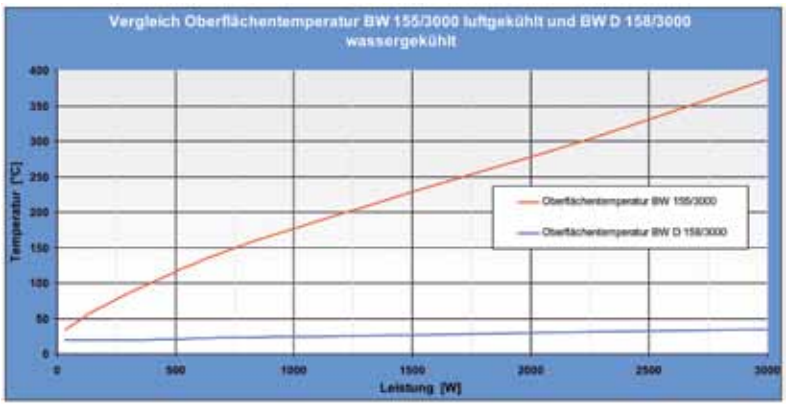
Are available with power levels from 1 to 100 kW. Cooling channels introduced into the heat sink enable efficient cooling and the spatial separation of the electrical conductors- and coolant - enabling safe application. In addition to the general advantages of the REOHM braking resistors, such as modular construction to attain higher power levels or the compact design, the braking resistors have an optimal structure and power consumption, enabling them to also withstand vibration and shock tests. REOHM braking resistors are an optimized combination of proven and innovative techniques, so that nothing stands in the way of its use with high power classes under conditions of limited space especially when using water cooling.

Series REOHM BW D158 /1600

- Braking and load resistance for the drive technology, industrial applications.
- Power: 5 – 100 kW
- Cooling channels series BW D 158: Aluminum (AlMgSi 0.5) Di = 10.5mm
- Cooling channels series BW D 160: Copper or stainless steel Di = 10 mm

Type:	BW D 158
• Power:	1 – 100 kW
• Protection:	IP 20 ...IP 65
• Resistance values:	0,2-850 Ohm

Type:	BW D 160
• Power:	5 – 100 kW
• Protection:	IP 20 ...IP 65
• Resistance values:	0,2-850 Ohm



Comparison of an air-cooled braking resistor with a liquid-cooled braking

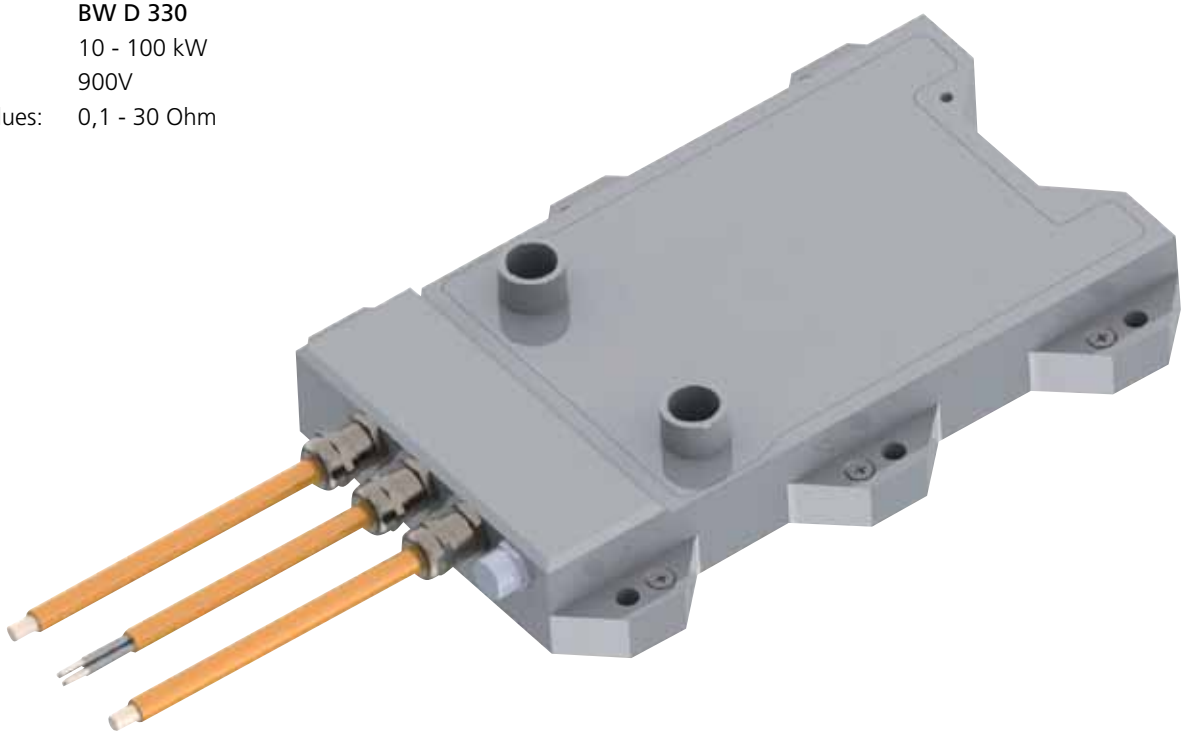
	BW 155/3000 air cooled	BW D 158/3000 watercooled
Dimensions (LxWxH):	762 mm x 175 mm x 75 mm	320 mm x 50 mm x 68 mm
Space required :	0,134 m²	0,05 m² - **60 % Platzersparnis**
Surface temperature with a full load:	387 °C	35 °C **90 % smalle surface temperature**

Series REOHM BW D330

- This series BWD 330 is available as loading or damping resistor or braking resistor for railway technology with capacities up to 100 kW.
  Liquid cooling enables space savings up to 88%. As a special bonus, the resistor can be connected easily via non-drip quick connectors.

- 88% space savings
- dripless quick-connections
- Watercooling
- electronic control

Type:	BW D 330
• Power:	10 - 100 kW
• Voltage:	900V
• Resistance values:	0,1 - 30 Ohm



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