

REO Liquid Cooling

Product catalogue for inductive
and resistive components

High efficiency and low noise levels • Minimization of construction sizes • Effective cooling • Very low excess surface temperature • Increase o

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REO liquid cooling - An Increase in Effectivity

Traditional methods of air cooling encounter their limits at the latest when limited space refuses to permit optimal air circulation from being realized or, due to high temperatures, cooling using the ambient air is not possible. The water cooling (liquid cooling) method is a very efficient option for drawing heat away from a heat source. The heat is transported with the high heat capacity and density of the coolant. This makes this type of cooling more efficient than traditional air cooling. Very high cooling power densities are possible.

As an example, we will consider a comparison between air cooling and liquid cooling:

- assumed power loss: 3200 W
- temperature difference to be reached: 5K

Calculation of the coolant volume required:

$$\begin{aligned} \text{Air:} \quad & \dot{V} = \frac{Q}{\Delta t \cdot \rho \cdot c_p} = \frac{3200}{5 \text{ K} \cdot 1 \cdot 1007} = 0,65555 \frac{\text{m}^3}{\text{s}} = 655 \text{ l/s} \\ \text{Water:} \quad & \dot{V} = \frac{Q}{\Delta t \cdot \rho \cdot c_p} = \frac{3200}{5 \text{ K} \cdot 983 \cdot 4179} = 0,0001557 \frac{\text{m}^3}{\text{s}} = 0,1557 \text{ l/s} \end{aligned}$$

In order to achieve a cooling of 5K with power dissipation of 3200W, 655 l/s air is required or only 0.1557 l/s water. This illustrates the significant advantage.

Applications:



Industry



Train technologies



Renewable energies

Comparison of common cooling methods:

In the following example, the 4 common cooling methods will be compared. This will display which types of heat can be converted on a surface of 10 x 10 cm and a temperature difference of 30K.

Example: $Q = h \cdot A \cdot (T_2 - T_1)$; Surface = 10 cm * 10 cm ; temperature difference = 30K

Example			
Natural convection	Forced air cooling	Water cooling (recirculating cooling)	Immersion cooling
Heat transfer coefficient	Heat transfer coefficient	Heat transfer coefficient	Heat transfer coefficient
$h = 5 - 30 \text{ W/m}^2\text{K}$	$h = 20 - 400 \text{ W/m}^2\text{K}$	$h = 100 - 1600 \text{ W/m}^2\text{K}$	$h = 800 - 10000 \text{ W/m}^2\text{K}$
$Q = 2 - 9 \text{ W}$	$Q = 6 - 120 \text{ W}$	$Q = 30 - 480 \text{ W}$	$Q = 240 - 3000 \text{ W}$
- Free convection	- Free + forced convection	- Forced convection	- Free convection

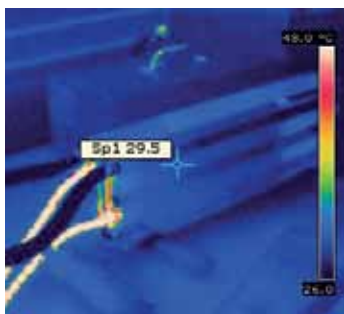
Using water-cooled systems, one can convert significantly higher capacities on the same surface - from which the increased cooling efficiency arises.

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 variously designed 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

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.



The illustration shows a water-cooled REO braking resistor. The infrared recording allows the temperatures of the cables to be easily seen, while the resistor is kept at an optimal temperature with water cooling.

Advantages of liquid 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)

REO cooling variants

Cooling using a cooling plate

The cooling occurs using cooling plates, which mechanically separate the cooling circuit from the electrical power circuit. Thus the electrical, active components have no contact with the coolant.

Here, REO can offer you 2 variants:

1. Variant C:

In this variant, a heat sink will be attached to the component from the outside to cool it. This variant is especially interesting for low power levels and small components.

Example: Reactor CNW MC 903 or braking resistor BW C 152

2. Variant D:

In variant D, the heat sinks are integrated into the components and directly affixed to the heat sources in order to enable a higher degree of efficiency. This design is very interesting at high power levels. Example: Reactor CNW MD 903 or braking resistor BW C 158

Direct liquid cooling

Here, the electrical, active components have direct contact with the coolant. The coolant flows around the electrically active part or directly flows through it - this is the most efficient method of cooling; at the same time, however, a number of conditions must be observed.

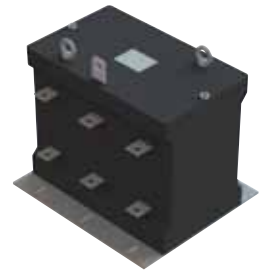
When developing and constructing water-cooled components, REO places increased value on the seamless integration into existing systems. However, the construction of its own cooling solutions, from which the customer application can benefit, has also been realized. Therefore, REO offers individual components or complete solutions as a switch cabinet version, specially for water-cooled drive systems in the larger power spectrum.



**Greater achievements
on the same surface**



Variant C:
Braking resistor
BW C 153 with
external heat sink

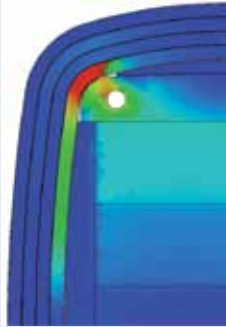


Variant D:
Directly cooled
motor reactor
CNW MD 854



**Greater achievements
on the same surface**

Design of liquid-cooled components



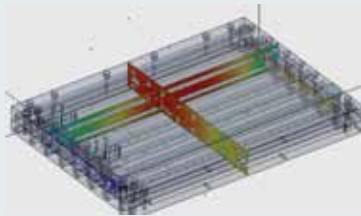
To develop liquid-cooled components, simulation plays a decisive role - with the help of various simulation techniques, cooling and coolant flow can be tested and optimized early during development and construction. This prevents later problems during construction or with the client.

Possibilities of simulation with REO:

- Simulation of gas and fluid flows
- Calculation of pressure, radiation, solid state temperature, fluid temperature, velocity, and density
- Thermal effect on the environment

Agreement on the cooling channel materials

Generally, connections made of brass-plated nickel or stainless steel are used. What is important here is an agreement concerning the materials for the cooling channels. All hoses, seals, and components have a sufficient temperature resistance of $> 100\text{ °C}$.



Using simulation procedures, the thermal effect on the environment can be reviewed, among other things.

The performance data in the data sheets are valid under the following conditions:

Maximum ambient temperature:	40°C
Max. inlet coolant temperature:	25°C
Max. coolant discharge temperature:	45°C
Operating pressure:	4 bar
Test pressure:	6 bar



Attention!!! In case of insufficient cooling or incorrect installation, the components may become overheated or damaged. Other temperatures, levels of power, and pressures are available upon requests. Solutions with higher coolant temperatures are also available.





RECUM BW 2 330/70008
BY: S80000-XX-XX
70W/80
IP 67
Seri N. 0001

Liquid-cooled REOHM resistors

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 electricity- and liquid-carrying lines - enabling safe application. In addition to the general advantages of the REOHM braking resistors, such as a more modular building 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 when using water cooling.

Series REOHM BW D158 / 160



Safe to use

- Braking and load resistance for the drive technology, industrial applications. Test fields and rail technology with integrated water cooling
- 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

Technical Data

Type	BW D 158	BW D 160
Power	1-100 kW	5-100 kW
Protection type	IP 20 ... IP 65	IP 20 ... IP 65
Resistance values	0,2-850 Ohm	0,2-850 Ohm



Advantages of liquid-cooled resistors

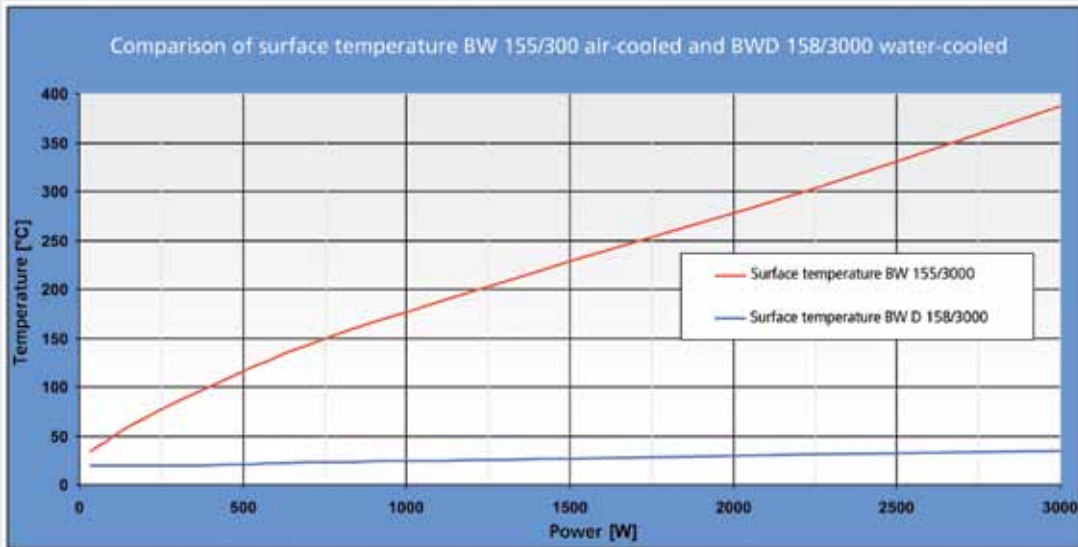
Comparison air-cooled/liquid-cooled

Type	BW155/3000 air-cooled	BW 158/3000 liquid-cooled
		
mechanical dimensions (LxWxH)	762 mm x 175 mm x 75 mm	320 mm x 150 mm x 68 mm
Space required during installation	0,134 m ²	0,05 m ² , 60 % space saved
Surface temperature with a full load	387°C	35°C, 90% lower surface temperature

BW 155/BW 158

Advantages of liquid-cooled resistors

The diagram illustrates the efficiency of water cooling using a measurement carried out on an air-cooled and a water-cooled REOHM braking resistor. If the



air-cooled resistor with a power level of 3000 W has a surface temperature of 387°C, the surface temperature for a water-cooled resistor is 35°C at the same power level.

35°C surface temperature at 3 kW

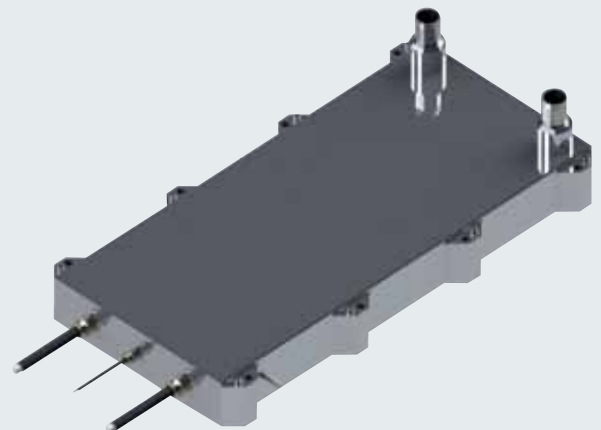
New resistor series for higher power levels for automotive and testing field applications in addition to industrial applications.

Series REOHM BW D330

Very compact dimensions and effective cooling. The goal here is not to cool the component but also to use the dissipated heat and make it available to the user.

The BW D330 is also available in very compact construction with an integrated

Technical Data		BWD 330
Type	BW D 330	
Power	up to 25 kW (adaptable)	
Protection type	IP 20 - IP 66	
Resistance values	1-100 Ohm	



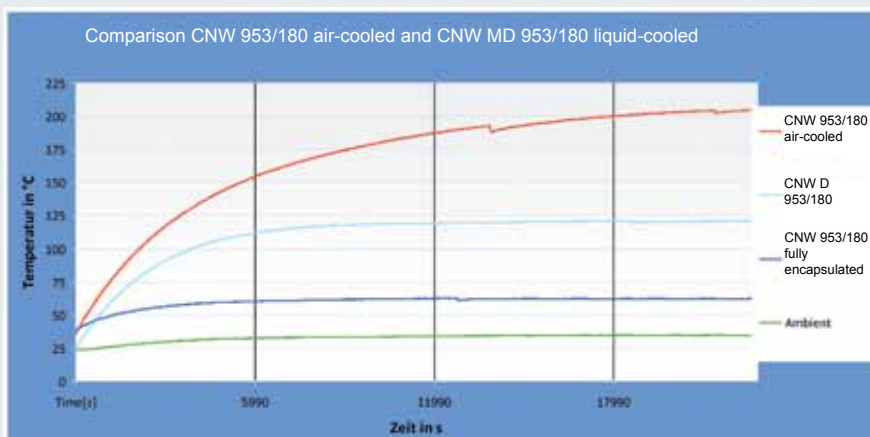
REOHM Resistor 60kW

braking chopper. Here, the resistor and chopper create a compact unit with a cooling system.

Liquid-cooled REO reactors

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.

Advantages of liquid-cooled reactors



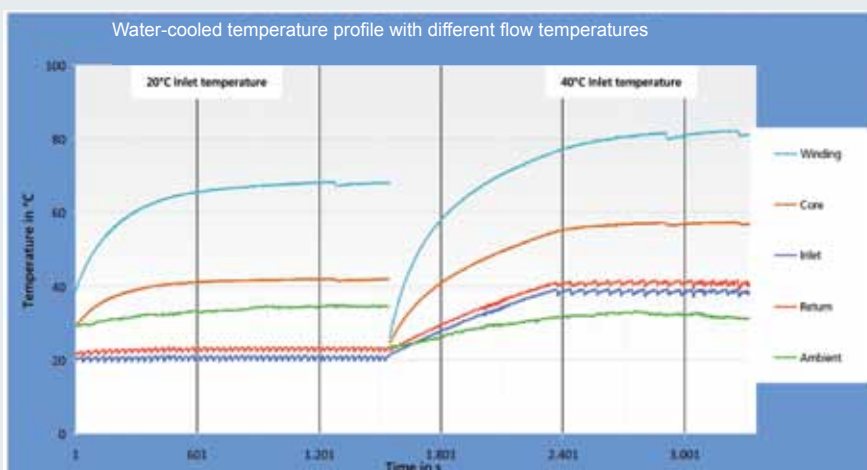
Max. temperature CNW 953/180 air-cooled:	205°C
Max. temperature CNW D 953/180 water-cooled:	120°C
Max. temperature CNW MD 953/180 water-cooled and poured:	68°C

The advantages of the water cooling method can be clearly seen based on the measurements.

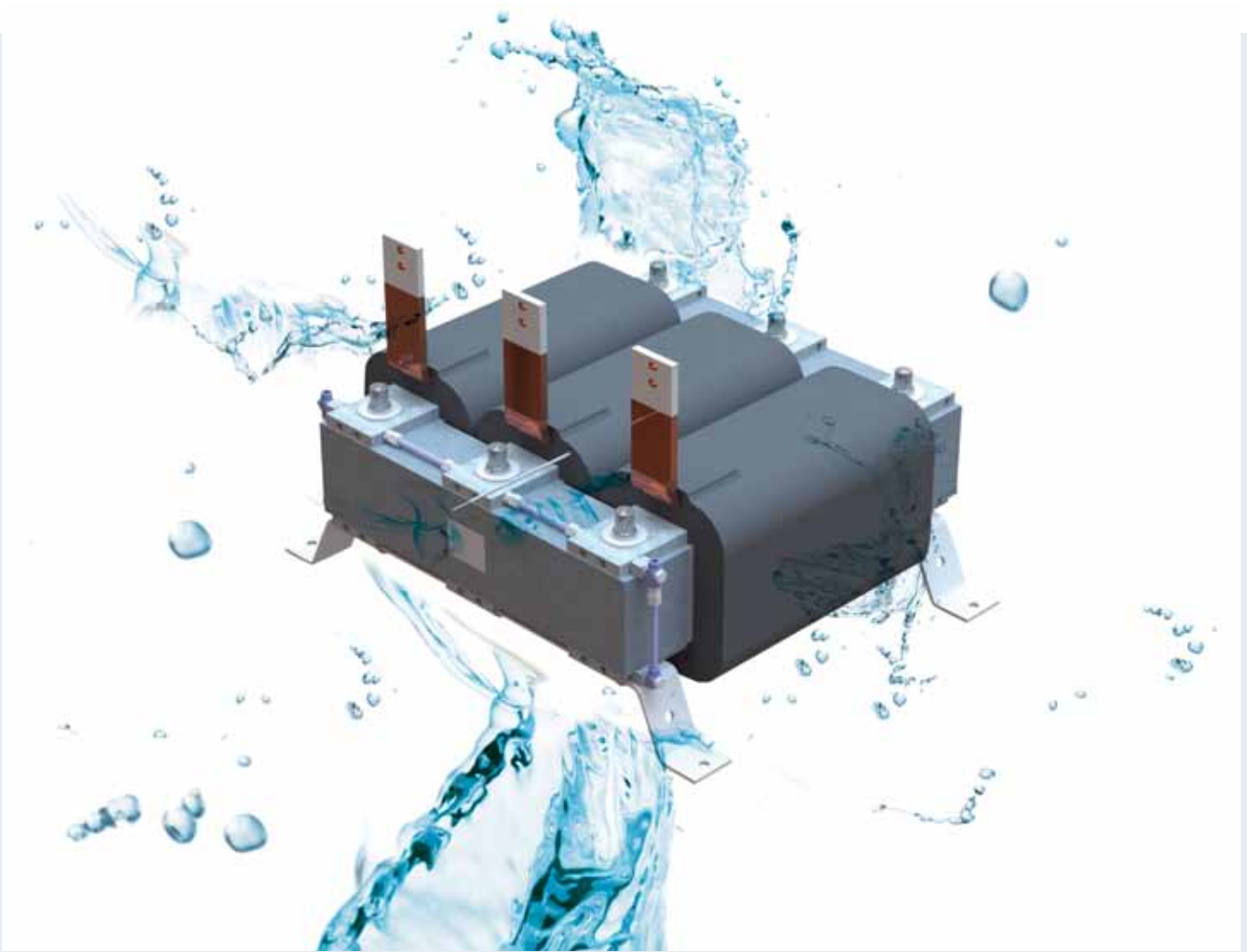
All 3 variants were tested with the same load; when doing so, the open water-cooled reactor had a temperature advantage of 52 K.

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.



Temperature advantage up to 137 K



Series CNW MC – for smaller components

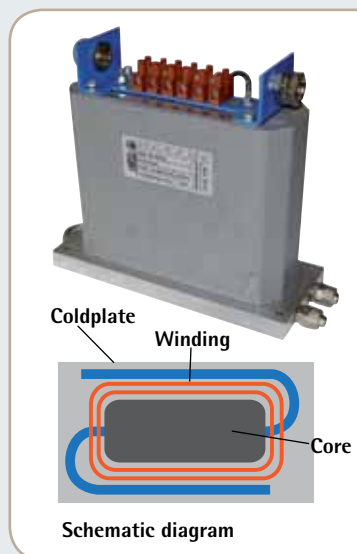
- Reactor cast on a metal plate, with integrated cooling channels. This component enables targeted and optimized cooling for smaller power levels and is characterized by its simple integration into existing cooling systems.

Technical Data

available in 4 different versions. (IP00, IP 20, IP 20+EMV and IP64)

Type	CNW MC
Current	6 - 70A
Protection type	IP 00 - IP 64
Inductance	0,4 - 10 mH

Series CNW MC – for smaller components



Coldplate-Choke CNW MC

- Targeted and optimized cooling
- Suitable for industrial water and standard cooling liquids
- Easy connection for liquid cooling
- Working pressure up to 4 bar (10bar test)
- Protection up to IP64
- Various connections: wires, terminals, terminal box
- Quiet
- Lower surface temperature

Series CNW MD - for medium to larger power levels

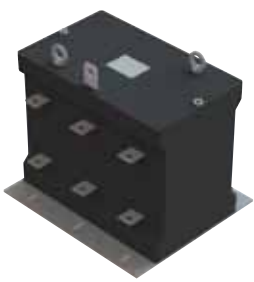
- For currents from 100 A - 400 A (Series CNW MD):
Chokes of the series CNW MD 400 are fully encapsulated or alternatively partially encapsulated. An encapsulation allows in interaction with the liquid cooling a better heat transfer than the same component not encapsulated. The encapsulation allows a protection class up to IP 65.

Liquid-cooled choke CNW MD

- Targeted and optimized cooling
- Suitable for industrial water and standard cooling liquids
- Easy connection for liquid cooling
- Pressure drops to ≤ 0.6 bar
- Degree of protection up to IP 65
- Various connections: wires, terminals, terminal box
- Quiet
- Lower surface temperature

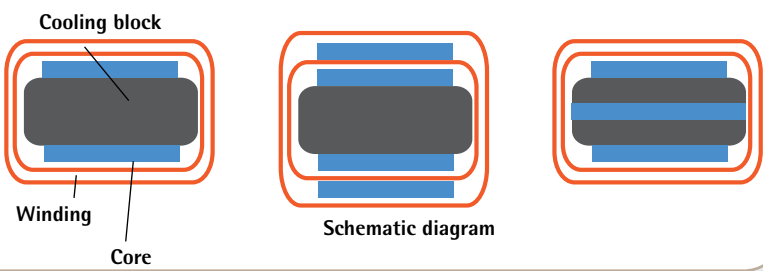


Single coil encapsulation



Fully encapsulated version

Example for different concepts of liquid-cooling



- For currents of 400 A - 2000A (CNW MD):
CNW MD chokes up to 2000 A are partially encapsulated. The partial encapsulation enables an optimum heat transfer while reducing weight. The number of cooling profiles are customized.

Technical Data		
	Open design	Fully encapsulated version with water pockets
Type	CNW MD	
Current	100 - 1200 A	
Protection type	IP 00 - IP 40	IP 00 - IP 65
Inductance	5 - 147 mH	5 - 200 mH

CNW MD - with cooling profiles

REO ColdPlate

is a sub-structure component especially developed for Coldplate Inverter. The REO-ColdPlate has cooling loops running through it that can be connected to a water cooling system. The customer can, for example, mount a Coldplate Inverter, IGBTs, rectifier switches, and other power electronic components onto the components, which can also be cooled via the REO-ColdPlate. This does not require an additional cooling plate and it will save installation space, volume, and material.

REOHM series BW D 158 CP

Substructure of braking and load resistors for the Cold Plate Inverter in drive technology, industrial applications, testing facilities, and rail technology with

Technical Data	
Type	BW D 158
Power	2,5 - 10 kW
Protection type	IP 20 - IP 65
Resistance values	1-800 Ohm

BW D 158 CP

water cooling. Components, such as converters, can be directly attached to the resistor and will be cooled with its water cooling.

Water-cooled sub-structure mains filter Cold Plate CNW MD 458

Technical Data	
Type	CNW MD 458
Rated voltage	480 V
Rated current	3-64 A
Protection type	IP 20 - IP 65

CNW MD 458

Compact sub-structure EMV filter with integrated water cooling for the Cold Plate Inverter in drive technology; industrial applications; testing facilities and rail technology with water cooling. The customer has the option to additionally cool his components via a cooling surface.



Simultaneous cooling of your components

Coldplate-Resistors



Coldplate-Mains filter



REO liquid-cooled combinations

It is also possible to build multiple components into one component and therefore obtain a compact unit. The cooling can be directly integrated, the cooling performance is increased and the component dimensions decreased.

Therefore, for multiple components, the customer only has 2 water connections, thus saving on the piping in the switch cabinet.

Directly liquid-cooled components

These special components are designed to the customer's specifications. Non-conductive liquids can be used as coolant liquids here (e.g. deionized water), although water can also be used. Here, specific framework conditions must be clarified with the customer.

In general, one could say the directly water-cooled components display the highest degree of efficiency in cooling.

Examples of directly water-cooled components:

Electrical conductor, directly cooled with deionized water.

REO Three-Phase Transformer

- NTT-3UI 210sp-DT6990
- Input voltage: 3 x 400 V, 50 Hz
- Output voltage: 3 x 38 V
- Input current: 3 x 100 A
- Output current: 3 x 1053 A
- Nominal power: 69 kVA
- Test voltage: 2500 V
- Protection type: IP00

Directly water-cooled resistor BW D 130

- Direct water cooling with connection to electrically active components
- Cooling medium: deionized water; water
- Nominal voltage: 600V DC
- Nominal power: 5kW – 25kW

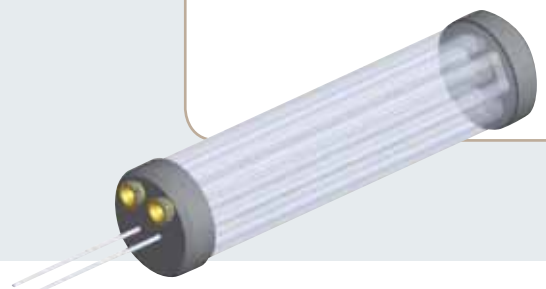
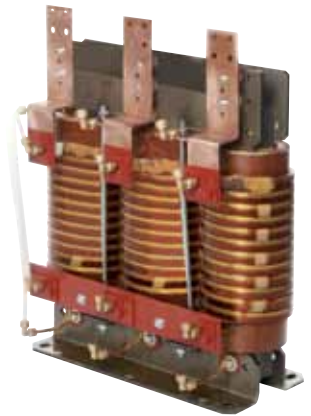
This resistor can also be used to effectively heat water and service water. The heat can therefore be used in other processes.



Minimization of component dimensions



Example:
Combination of EMV filter
and motor reactor with
water cooling
Nominal voltage: 3x 480V
Nominal current: 100 A



Liquid-cooled complete systems

REO not only offers individual components but also complete systems. Here, REO offers you its complete expertise from one source. Completely pre-wired solutions are offered.

Here, we can offer you solutions such as water-cooled load banks for test facility use, as well as complete EMV solutions for water-cooled inverters with increased power for wind, solar, and industrial applications.

Switch cabinet system 280A Liquid cooling for converter 135 kW

- **Complete switch cabinet for applications**
3x 480V / 280A
Construction:
 - EMC filter CNW 107.3/280
 - Line reactor CNW MD 903/280
 - Motor reactor CNW MD 854/280
 - Brake resistor BW D 158
 - 50 kW at ED 100%
 - 95 kW at ED 50%
 - 325 kW at ED 10%
 - Cooling circuit, laid out for water-glycol mixture
 - Water distributor with regulated cycles
 - Electrical connection: copper rails

Systems for water-cooled drives in a larger performance spectrum than a complete solution in a switch cabinet.

Resistor load for test equipment

- **The module design is suitable for any load unit in the laboratory and is designed for laboratory and development institutes as a variable unit.**
 - According to: EN 50178
 - Test voltage: 8.6 kV for type 301/207
 - Protective type: IP 20
 - Ambient temperature: 40°C
 - Nominal voltage: 230/400V
 - Nominal power:
 - DC 1 82.5 kVA
 - AC 1 3x 23 kVA
 - AC 2 3x 70 kVA
 - Modular compact design
 - Various circuit configurations
 - Can be used as a single or three-phase load unit
 - Higher power levels and other voltages upon request
 - Cooling: Water cooling for water – glycol mixture

Coolant liquids

Typical coolants and material suitability

1. Water

- Percentages of calcium, magnesium, hardness, chloride, and sulfate can lead to deposits and corrosions.

2. Deionized water

- Also called demineralized water
- All ions, calcium, sodium, iron, copper, chloride, bromide, salt, and impurities have been removed
- The higher the insulation effect, the higher the corrosiveness

3. Glycol and aqueous solutions

- Ethyl – glycol water has very good physical properties but is toxic
- Propylene glycol water has slightly inferior properties but is better suitable for use in the food industry.

4. Salt water

- Deposits and severe corrosion
- Contamination must be taken into consideration

5. Deionized water

- Distilled water
- Very suitable for microchannels
- No electrical charge or mineral deposits
- Very aggressive and unusually corrosive

6. Non-conductive liquids - Dielectric liquids have properties similar to deionized water and are not very corrosive

Which cooling liquid for which material?			
Copper	Aluminium	Stainless steel	Liquid
x		x	Water
x	x	x	Glycol
x		x	Oils
		x	Salt water
		x	Deionized water
x	x	x	Non-conductive liquids

To safely operate the equipment, the VGB cooling water guidelines must be strictly adhered to (VGB-R 455 P).

The most frequent contaminations in industrial cooling systems are:

- mechanical contaminations
- Excessive hardness
- Chemical contaminations
- Biological contaminations, e.g. algae, bacteria

In the standard design, the maximum inlet temperature is + 25°C and the maximum discharge temperature is + 45°C. Higher or lower temperatures are available upon request.

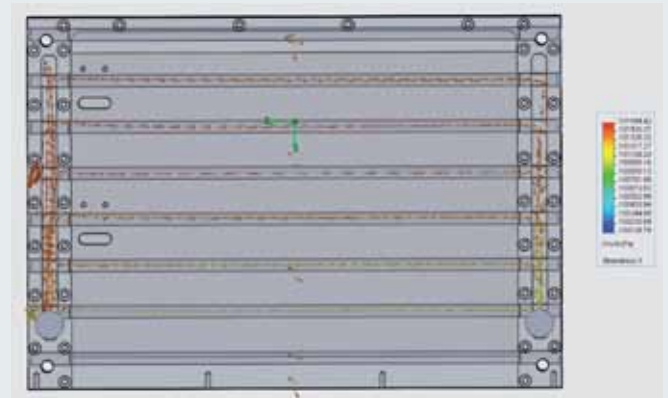
Pressure loss

Every component has a pressure loss that is very important for the design of the cooling system and the coolant pump. The coolant loss is a pressure difference created by wall friction and internal fluid friction in pipelines, fittings, valves, etc.

The resistor number z for components can be taken from table works. The resistor number itself can be dependent on volume flow, geometry, Reynolds number, etc.

Calculation of the total pressure drop when connecting multiple cooling components

- Determination of the individual pressure drops
- Calculation of the total pressure drop according to the following formulas:
- Determination of the pressure drop of the entire system



The pressure losses can be determined in advance using simulation procedures and calculation programs.

Calculation of the total pressure drop

Series connection

$$\Delta P_{\text{Total}} = P_1 + P_2 + \dots$$

Parallel circuit

$$\Delta P_{\text{Total}} = \frac{1}{(1/P_1) + (1/P_2) + \dots}$$

Temperature monitoring

Because of the small and compact component, the cooled components would overheat and be destroyed without the water cooling system. Therefore, for the water-cooled series, the temperature of the components can be monitored by means of a temperature switch. If a nominal temperature is exceeded, the temperature switch opens and triggers an alarm contact. The temperature switch is equipped with 2 wires that are ready to be connected. Therefore, if the water cooling fails, the system will be turned off.

Important information about the design



Liquid-cooled series with optional temperature switch

Connections

<p>1. Standard thread AG or IG – Customer has the option to screw in his connections himself (very cost-efficient)</p>	
<p>2. Threaded sleeve Material: Nickel-plated brass / stainless steel Inner hose diameter: 2 – 32mm</p>	
<p>3. Plug-in connectors Material: Nickel-plated brass / aluminum Hose diameter: 6 – 12mm</p>	
<p>4. Hose screw connection Material: Nickel-plated brass / stainless steel Hose diameter: 4 – 17.6mm</p>	
<p>5. Separable hose connector low drip / non-drip</p>	

1. Coolant

Which coolant is used? - Important for material selection and the design of the cooling system.

2. Cooling channels material

Which other material is used in the system??

Important for durability and design!!

E.G. Copper and aluminum may not be used in a circuit, otherwise a chemical reaction may occur between both materials, which could lead to destruction of the pipes.

3. Flow volume

Important for the design of the cooling system and the components!!

REO gives standard values in the data sheet.

Deviations from this data must be inspected.

4. Pressure drop

Important for the design of the cooling system and the interconnection of the cooling channels

5. Max. temperatures of the coolant during supply and return

Very important for the component design and the fulfillment of the customer's requirements.

6. Connections

A threaded connection is standard. REO also offers a wide spectrum of water connections.

Connection variants

Generally, connections made of brass-plated nickel or stainless steel are used. What is important here is an agreement concerning the materials for the cooling channels. All hoses, seals, and components have a sufficient temperature resistance of > 100 °C. The most common connection variants are displayed in the following table. We will be happy to offer you other connection variants upon request.

Applications



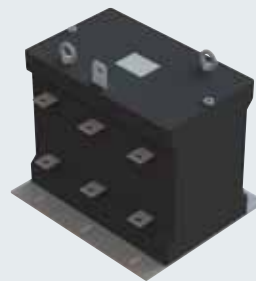
NTT RD 158
Water-cooled resistor for rail technology
Nominal voltage: 4.2 kV / DC



BW D 330/40000
For use in vehicles.



NTT BW 158
Braking resistor 10 kW for the Project
Coaster



Choke CNW MD 953/180
Nominal voltage: 480V
Nominal current: 180A



Choke CNW MC 933/340
Nominal current: 340A
Test voltage: 2.5 kV



Combination EMV filter + PFC resistor
Nominal voltage: 480V
Nominal current: 50A / 100A



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