Railway Resistors

For on-board and substation installations

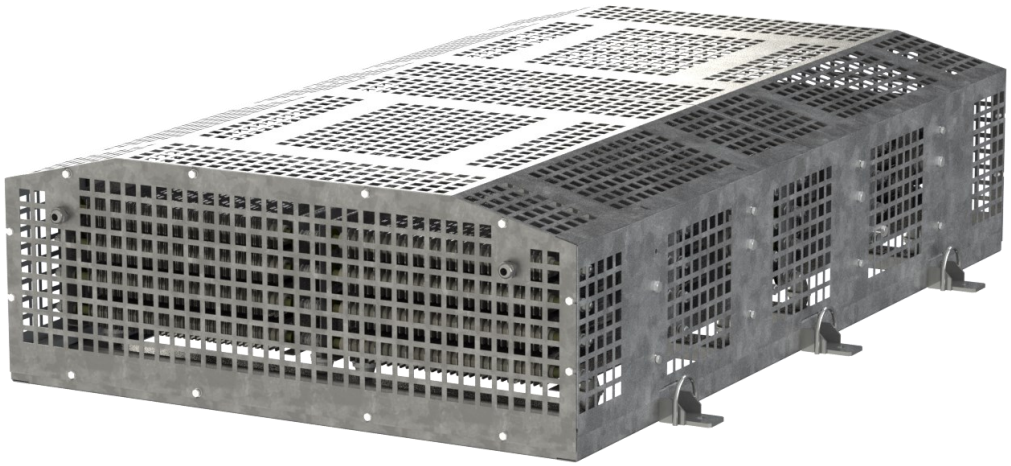
Traction Brake Resistors

(De) charging Resistors

Damping and Filter Resistors

Crowbar and Line-test resistors

BACKER FACSA



Railway Resistors

There are many different types of railway transport; trams, metro, Light rail or (high speed) trains, and they all need resistors for different kinds of applications. Conventional disk brakes are used together with modern electrical brake systems to prevent the disk brakes from great wear. On board auxiliary systems generate noise, by use of high switching power semiconductors, which needs to be filtered out of the system to improve energy quality. Starting up electronic systems would in general cause high impulse loads that could damage electronic components. To prevent this, charging resistors are used to safely but fast charge the system. For safety, de-charging electrical circuits is done with the same principle but normally over a longer time. In stationary systems (substations), resistors are used to check the overhead-lines before powering them. This to prevent damage to the High Speed Circuit Breaker in case of any faults.

The position of the resistor, whether it is under the frame of the vehicle or on top or inside the wagon determines the type of resistor to be used. In almost all cases the needed resistor is tailed to the available space and cooling conditions. Backer–Facsa Resistor Division, studies the scope of the demands and by using sophisticated 3D engineering software, create the optimum resistor solution in technical and commercial aspect.

High power resistors need to be forced air cooled to be able to expel the excessive energy to the ambient air. The airflow can come from the outside as the vehicle is moving but can also be generated by electrical ventilators.

Especially for railway many directives apply. Directives on voltage insulation level, ingress protection, shock and vibration and maximum temperatures of used materials determine the design of the resistor. Tests can be performed in-house or at nearby testing facilities. If required such tests can be witnessed by an accredited third party certification institute.

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Backer–Facsa Resistor division has its office and production in Llanera–Asturias in Spain. Our engineers are highly experienced in the field of design, production and testing of steel grid type resistors. Backer–Facsa Resistor division has obtained the ISO9001 certificate. The quality system is implemented in the whole process; starting from the request of the customer until the shipping of the resistors.

Steel grid resistors for Railway applications are used in harsh environments where very low and high temperatures and high mechanical forces occur. The resistor is build up with nickel-chrome alloy sheets with exceptional good thermal, electrical and mechanical properties. The material is corrosion protected. The resistor elements are welded together, building up resistor blocks. The blocks, placed on insulators, are fitted into cabinets or mounted with support brackets for further mounting.

Backer–Facsa S.L. steel grid resistors for Railway applications comply to international standards.
For special demands or directives, please, contact our sales organization for further assistance.
Our goals is to be part of your success.

Backer–Facsa
Resistor Division
Llanera–Asturias
Spain

Traction Braking Resistors

Braking a Railway vehicle is mainly done by electric resistors. Mechanical brakes wear out too quickly and require expensive maintenance. During braking, the kinetic energy of the train is transformed into electric energy and if possible, fed back to the overhead line but this can only be done if another vehicle is connected to the same overhead line and can use the energy. If this is not possible, then the energy must be dissipated as heat in onboard resistors.

There are multiple railway vehicles application, each with its own demands, legislation and directives. Although in the real meaning of the word trolley and (hybrid) electrical busses are not railway application, the same type of resistors can be used here too. Each type of transport, whether it is tram, metro, light rail or (high speed) train, have unique demands on the type of resistor. Ambient conditions such as air temperature, humidity, mechanical forces, national and international directives, play an important role in the selection of the materials to use and the construction of the resistor.

There are three possible locations for the brake resistors:

- On the roof of the train where the hot air is released upwards
- Under the frame of the train where the hot air is released to the side
- Inside the vehicle in special compartments.

All locations may use natural convection or forced-air cooling.

Main parameters

Nominal voltage

Braking energy

Braking time

Mounting location

Cooling (forced-air or natural convection)

Dimensions

Railway applications standards:

IEC 60322:2001	Electric equipment for rolling stock - Rules for power resistors of open construction
IEC 61373:2010	Rolling stock equipment - Shock and vibration tests
UNE-EN 50124-1:2001	Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment.
UNE-EN 50125-1:2001	Environmental conditions for equipment - Part 1: Equipment on board rolling stock.
ANSI/IEC 60529-2004	Degrees of Protection Provided by Enclosures (IP Code)

Charging a Capacitor Bank

A DC capacitor bank must be charged in a controlled manner to prevent damage to the rectifier bridge. High inrush currents could destroy components such as diodes or thyristors. Placing a resistor in the charging circuit limits this current and protects the semiconductors, avoids line-voltage sag in the case of a weak grid and prevents the capacitor voltage from over-shooting.

Using a resistor for charging the system is a safe an commercial attractive way to do. The resistors are compact, light weight and almost maintenance free. Charging resistors can be fitted into the inverter housing as they don't generate high energy losses. However, during charging high power loads occur. It is the physical properties of the resistor, mainly determined by active conductor mass and cooling that give the resistor its unique features.

DC capacitor bank charge resistors for railway applications are often used in high voltage circuits. Special consideration is taken when designing resistors for high voltage applications for insulation coordination, creepage and clearance distances .

Discharging a Capacitor Bank

The dangerous high voltage due to the energy stored in a capacitor bank needs to be discharged in a controlled way. Safety regulations require that dangerously high voltages must be below a safe voltage level within a certain time (normally 1 or 2 minutes). A discharge resistor switched across the capacitor bank after the system is turned off, is a reliable and cost-effective way of ensuring this.

The difference between charging and de-charging is mainly the duration time the process takes. Normally, charging a capacitor banks is done within one second up to a few seconds. De-charging is allowed to take a longer time, however, normally it is limited to 2 minutes. The longer de-charging time requires high ohm resistors. If the resistance values are too high to make the resistor with steel grid plates, ceramic wirewound resistors are used. The resistor parts, whether they are steel grid types or ceramic wirewound types, are fitted into a box. Creepage and clearance distances are observed and at the same time minimum distances from the active (hot) elements not to heat up any neighboring components.

Main parameters

Voltage

DC link capacitance

Time constant

Cycle time

Damping and Filter Resistors

Filter resistors

Harmonic Filter Resistors are used to attenuate harmonic frequencies that would otherwise perturb the power grid. In any application where power semiconductor switches are used, such as in propulsion drive inverters and onboard auxiliary power supply inverters, harmonic voltages and currents are generated causing additional losses and interference with other electrical circuits. Harmonic Filter Resistors are used in combination with capacitors and inductors. The filter passes the fundamental frequency through and dissipates the harmonic currents into heat. The power dissipation depends on the sum of all attenuated harmonics.

Filters are build up from inductors, capacitors and resistors. In principle a filter can be build using a capacitor and an inductor. Such a filter will pass through the voltage with the basic frequency while blocking all other frequencies. A disadvantage is that this filter is very sensitive for small changes in the capacitance and inductance values (due to manufacturing, aging and or temperature influences). This can be improved by adding a resistor to the filter. Filters can be divided into different types. For power grid system the most common used are the low pas filter (LRC) and the RC filter.

A filter resistor must have a stable ohmic value, independent from temperature. By using special alloys as active resistor material this is achieved. The parasitic inductance should be as low as possible for proper filtering.

Damping resistors

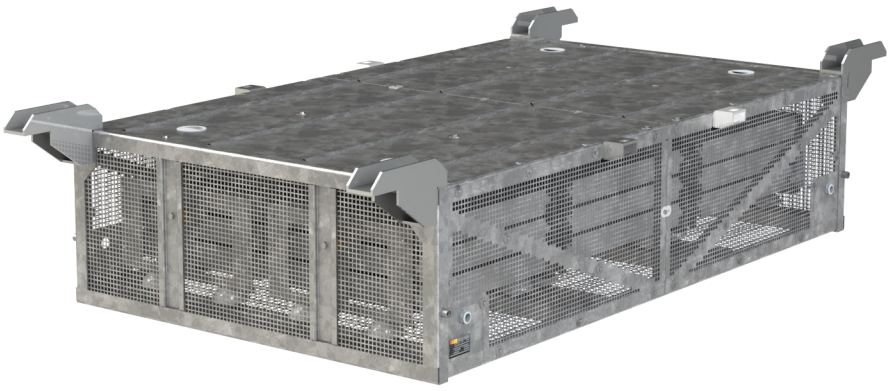
The difference between damping resistor and filter resistors is that damping resistors limit any current and voltage peaks where filter resistors take out higher harmonics that disturb the voltage shape. Damping resistors prevent any damage on other (electronic) components where filter resistors improve the quality of the power grid.

Main parameters

Ohmic value at rated current and or cold state
Total (harmonic) power dissipated in the filter resistor
If applicable, short time current capability
Insulation voltage level
Cleerance and creepage distances

Additional parameters

Maximum inductance
Connection / terminal layout
Mounting: stacked or side-by-side
Environment



Crowbar and Line-test Resistors

Crowbar Resistors

Crowbar resistors are used to suppress transient or short-duration voltage peaks and can also be used to control longer lasting over-voltages. Two different types of crow bar resistors can be defined; a soft crowbar that handles short duration voltage peaks and a hard crowbar that will be switched on to eliminate the longer lasting over-voltages. If the hard crowbar is switched on it will short circuit the whole inverter and by that protecting it against high voltages. Other, necessary installed protection devices like fuses will safely interrupt the power to the inverter.

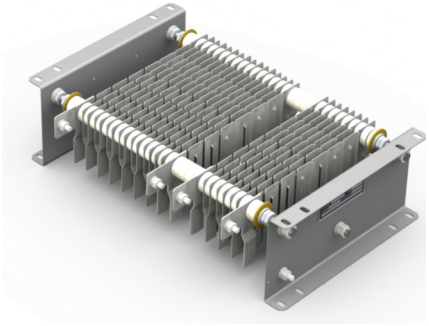
Crowbar resistors are designed to handle high power loads for limited periods. They are compact, light weight, low maintenance and very reliable. Designing a crowbar resistor starts with the main parameters. The total energy it must be able to absorb is directly proportional to its weight. During very short times, the dissipated energy will increase the active element temperature to its maximum value.

Main parameters

Ohmic value

Voltage

Energy



Line Test Resistors

Line test resistors for railway applications are used to detect fault conditions on overhead lines (catenaries) before switching on the power. To prevent damage to the High Speed Circuit Breaker in case of any faults, the line-test resistor is switched to the line and if no fault current is detected it is deemed safe to close the HSCB (High-Speed Circuit-Breaker). HSCB lifetime is inversely proportional to the number of fault clearances. Indeed, it may be required that such a test (with fault conditions) be repeated several times in a row and these resistors can help to locate the faults when several short line-tests are applied.

Line-test resistors are able to handle a specific number of test cycles with fault currents. The more (often) the line-test is repeated the bigger the size of the resistor must be. Same time, a pulsed line-test can help to resolve the fault conditions by clearing any humidity or ice layers on the insulators carrying the overhead lines.

Main parameters

Nominal voltage

Test current

Duty cycle

Test Facilities

For each application, specific standards apply. Standards define requirements, terminology and test procedures. These tests involve, but are not limited to; resistance test, insulation test and dielectric test.

Resistors for rolling stock (Traction applications) often need to conform to International Standard IEC60322. In this standard, requirements are specified, not only for the resistance, insulation and dielectric testing but also for the maximal temperatures of the various parts of the resistor and maximal temperature increases. Fire prevention and materials susceptive to fire, toxicity and smoke are all related.

Shock and vibration testing are also covered by this standard.

Backer–Facsa designs, tests and qualifies resistors according to Railway and Utility standards.

There are two different kinds of tests; type tests and routine tests.

Type tests are done for all new resistor designs or where there is a contractual agreement with the customer to perform such test under new or different conditions. The type test normally verifies the maximal temperature at maximal load, the ingress protection level and the insulation voltage withstand.

Routine tests are performed at the end of the fabrication process, for all resistors:

- measurement of the ohmic value
- measurement of the inductance value
- dielectric test 50Hz/1 minute between active part and housing, from 0 up to 120 kV as specified in IEC 298.

Verifications according to manufacturing quality control procedure, consisting of:

- verification of the dimensions according to the specification drawing
- verification of the IP class per IEC 144
- sight inspection of the different components.

Backer-Facsa Resistor division is able to test resistors up to 80kW continuously. Using FLIR thermal cameras hotspots are revealed and in particular, electrical connections are examined for any poor contacts.

Insulation voltage test is handled by a High Voltage ALT-120/60 AC HiPot tester with a continuous load rating of 3.6kW resistive and 7kVA capacitive.

A factory test certificate is established during these tests per our Quality Control procedure.

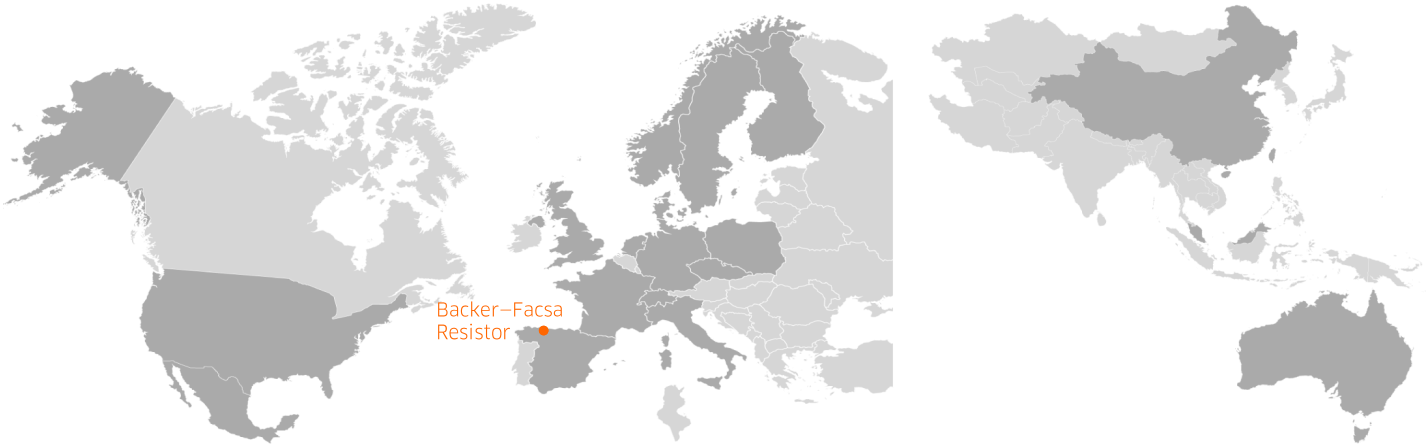
A witness test in our facilities can be arranged on request and customers can be informed one month in advance of the exact test-date.

ALT-120/60

FLIR thermal image

80kW continuous power cabinet

Backer World Wide



North America Europe Asia / Oceania

Backer–Facsa Resistor Division

engineers and produces resistors for railway applications based on customer requirements. Each resistors needs to be tailored to the space available and cooling method. The resistors comply to the railway traction directives for insulation voltage level, ingress protection, shock and vibration and maximum temperatures of used materials. Tests can be performed in-house or at nearby testing facilities. If required such tests can be witnessed by an accredited third party certification institute.

Backer–Facsa Resistor Division in Llanera, Asturias in Spain is ISO 9001 certified. All resistors are subject to a routine test.

FAC EN15.5033.R2

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