

STEEL GRID RESISTORS



BACKER
FACSA



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Neutral Earthing Resistor



General Purpose LV Resistor



Filter resistor



General Purpose LV Resistor

Backer-Facsa S.L.

Backer-Facsa S.L. , Heating Elements Division is located in Aiguafreda, some 50km from Barcelona, Spain. The company FAC S.A. was founded in 1959 and mainly produced heating elements for both industrial and domestic applications. In the '80s, FACSA was the biggest heating-element manufacturer in Spain for washing machines and dish washers. In 2003, NIBE bought Facsa and the name was changed to Backer-Facsa S.L. NIBE is the leading manufacturer of heating elements in northern Europe and has production facilities in 19 countries in Europe, North-America and Asia. The total number of employees world-wide exceeds 10'000 people.

In Llanera, Asturias, in the northern part of Spain, Backer-Facsa has a resistor division that is fully dedicated to the design and production of steel-grid resistors. Backer-Facsa's engineers have a long experience of grid-type resistors as well as their numerous and growing applications. Whether it is in power distribution, renewable energy, industrial drives or public transport, resistors form an essential part of many of these applications.

All resistors are fully tested prior to shipment and where required, they can be tested according to special standards. Standards that are applicable to Traction or Power Distribution are studied during the design phase and tests are carried out to ensure their compliance. Backer-Facsa has its own test equipment but also has access to local external testing facilities where still higher test currents or voltages are needed.

Although resistors are generally seen as 'energy consuming' elements, they do improve overall system performance, simply by minimizing down-times. A good example of this is LVRT by which resistors allow wind turbines to keep producing energy during a grid fault where they would otherwise be switched off.

Backer-Facsa offers grid resistors for both low voltage and high voltage applications. Demands on insulation voltages, load, ingress protection, thermal ohmic drift, vibration withstand-capability, all determine the type of resistor needed. Thanks to a wide range of types and the ease of configuration, standard resistors can be used for most applications with and only minor customization being required for special customer needs.

At Backer-Facsa, all assembly and welding of resistor components and routine tests are performed in-house which ensures short leadtimes and high quality of the grid elements. High material-purchasing volumes ensure competitive pricing in this cost-conscious market.

The grid elements are manufactured using punching and laser-cutting machines and then assembled into resistor blocks. The stainless-steel stamped grids are spot-welded together, reinforced by two galvanized steel plates and insulated by steatite ceramic insulators. Together with the isolated connection bolts, they form the grid blocks which are then mounted into cabinets. The terminals are fitted and the inter-connections are made . Backer-Facsa also uses wire-wound elements for high ohmic resistors.

Backer-Facsa
Grid Resistor Division
Llanera– Asturias (Spain)

Tests and certificates

For each application, specific standards apply. For neutral-grounding resistors, one of the standards is IEEE Std 32-1972 which defines 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 susceptible 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 in LLanera, Asturias, 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

Renewable energy

Wind Turbine Low-Voltage Fault Ride-Through Resistors (LVRT Resistors)

Wind energy is a clean and costs effective way of producing power with no emissions contributing to global warming. This, plus its decreasing costs, make wind energy very attractive today. However, the more wind turbines are installed, the more we depend on their reliability and availability so that small grid disturbances should not lead to the turbines "dropping out". 'Grid codes' are specified by each country and/or by the larger electricity utilities to define the behavior of a turbine during such grid faults, These codes require that power flow should be maintained, which means it needs to be dissipated if the line cannot absorb it. Such resistors, known as "load dump resistors", must be able to dissipate the total power of the wind turbine during a short time. Steel grid resistors are cost-effective solutions for this application, as they have a high mass, which endows them with the high thermal capacitance needed to absorb this energy in a short time.

Wind Turbine Excessive Energy Dump Resistors

As stated above, wind energy is clean and cost effective. It has however one disadvantage: wind flow is not stable and can vary greatly over time. Strong wind gusts can lead to difficulties in feeding the energy into the grid where the grid has a limited power-absorption capability. If the turbine blades cannot be adjusted to reduce wind torque (through pitch control) then the wind turbine needs to be switched off during such gusts. By inserting a dump resistor to dissipate the excessive energy, the system can still feed the maximally acceptable power into the grid. Such solutions are very common in areas where the grid is weak or little energy can be diverted to other areas.

Wind Turbine Filter Resistors

In each wind turbine, an electronic inverter converts the energy from the turbine into a suitable form that can be fed to the grid. The electronic switches perturb the power quality which must then be conditioned by means of filters. Filters limit the harmful harmonics by diverting them away from the main load. Such a filter is composed of a capacitor and a resistor and sometimes an inductor. Filter resistors continually dissipate power during normal operation and should be thermally stable and of low inductance.

Wind Turbine Pre-magnetizing Resistors

The turbine output voltage must usually be matched to the grid voltage via a step-up transformer. As described earlier under "Energizing a Transformer", inserting (three-phase) resistors in series with the transformer during magnetization, limits the peak currents; once the transformer is energized, the resistors are by-passed.

Organic Rankine Cycle (ORC) Systems

In many generating systems, heat is involved but not all of this heat is used effectively to produce energy and the 'waste' energy is, in many cases, simply dissipated to the environment. ORC systems are able to recover some of this "low grade" waste heat and convert it into electricity. The basis for this is an evaporation process that occurs at low temperatures. The energy produced is fed to the grid and if a grid disturbance occurs, the system must be switched off. However, because of the long system time-constant, power flows until the system has come to a complete stop. This may take several minutes and the total energy needs to be dissipated. A resistor that can handle the power during a few minutes is connected, in case of such a fault and the resistor needs to have a relatively high mass to absorb all the energy. Steel-grid resistors are very well suited for such applications.

Neutral Earthing Resistors

Application

Neutral-earthing resistors (NERs) are used to ground the neutral point in a (medium) voltage grid. The resistors limit the fault current in the case of a phase-to-ground short circuit. A NER limits damage, resulting in shorter and fewer downtimes. The main advantages of NERs over alternative grounding methods is that they limit fault currents, allow simple fault-detection and do not produce over-voltages.

Main parameters

NERs are selected based on voltage, fault-current and duration-of-fault-current. Normally the resistor is chosen based on the energy [E] in joules that can be absorbed by the elements without exceeding the maximum element-temperature, energy being power integrated over time, where typical fault-times last 10 to 30 seconds. The power will vary slightly, depending on the resistance's temperature-coefficient. At the start of the fault, the current will be higher due to the resistor's lower ohmic value but as the elements heat up, the fault current will drop.

$$E = \int_0^T p(t) dt$$

NER Norms:

- IEEE-Std-32: "Terminology and testing procedure for Neutral Grounding Devices"
- EDF HN 64-S-50: French standard for NERs
- IEC 60071-1: Insulation Coordination



Additional parameters

IP Class (Ingress Protection):

Standard enclosures range from IP 00 (steel-grid building-blocks either with or without mounting feet) to IP 23 (protection against touching hazardous parts and against spraying water) with higher IP values available on request.

Enclosure:

Standard finishes are sheet-metal either galvanized steel DX51D+Z275-M-A-E, or mild steel painted in any RAL color. Customization is possible using stainless-steel types AISI 304 or AISI 316.

Note: Application at high elevations requires voltage and power de-rating – please contact factory.

Housing

The housing depends on the Ingress Protection class. The maximum standard IP value is 23. If a higher IP value is required, the NER must be protected from direct rain or spray. Steel-grid resistors can dissipate a great deal of heat which must be transferred to the environment. Though the resistors themselves can operate at very high temperatures, auxiliary parts, such as current transformers and other components, have lower temperature ratings; therefore, for higher IP classes, please consult factory.

Options

In many applications, a current-transformer is used to detect fault currents (typically with a secondary rating of 5A) and may be part of the whole construction of the NER.

The cabinet can be fitted with a heater to prevent condensation and contactors can be added to bypass the resistor.

Harmonic Filter Resistors

Application

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 wind-turbine inverters, variable-frequency drives or controlled rectifiers, 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; their power dissipation depends on the sum of all attenuated harmonics.

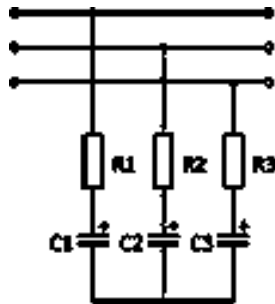
Typical applications for Harmonic Filter Resistors include High Voltage Direct Current (HVDC) networks and electric arc furnaces .

Filter resistor norms:

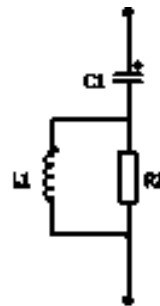
- CIGRE WG 14.30, resistors chapter

Main parameters

Nominal voltage
Current
Ohmic value



3 phase RC filter



LRC filter

$$P_{\text{RES}} = \sqrt{\sum_0^{\infty} I^2 \cdot R}$$

Additional parameters

Insulation levels; HV and LV terminal to earth and insulation level between terminals

Clearance and creepage distances

Maximum inductance

Connection / terminal layout

Mounting: stacked or side-by-side

Environment

Enclosures can be made of galvanized steel DX51D+Z275-M-A-E, mild steel painted in any RAL color or stainless steel types AISI 304 or AISI 316.



Filter resistor HV

Load Banks and Crowbars

Load Banks

Load banks are used for testing equipment such as (emergency) generators and UPS systems or also as dummy loads to maintain the generator at a minimum temperature. Load banks are offered from a few kW up to 10MW and from working voltages of a few hundred volts up to 36kV. Load banks are built from several steel-grid building-blocks making it easy to split up the load bank into (many) smaller loads. Load banks are made for both indoor and outdoor use in IP classes up to IP 23. Higher IP ratings are problematic as it becomes more difficult to dissipate heat.

Main parameters

Nominal voltage

Power

Number of steps and power rating per step

Type of ventilation: natural convection or forced air

Mounting position: horizontal or vertical (forced air only)

Additional parameters

Thermal drift: the difference in ohmic value of the resistor elements between cold and hot condition.

Ingress protection degree, IP20 / IP21 / IP23

Auxiliary components

Environment

Enclosures can be made of galvanized steel DX51D+Z275-M-A-E, mild steel painted in any RAL color or stainless steel types AISI 304 or AISI 316.



Crowbar Resistors

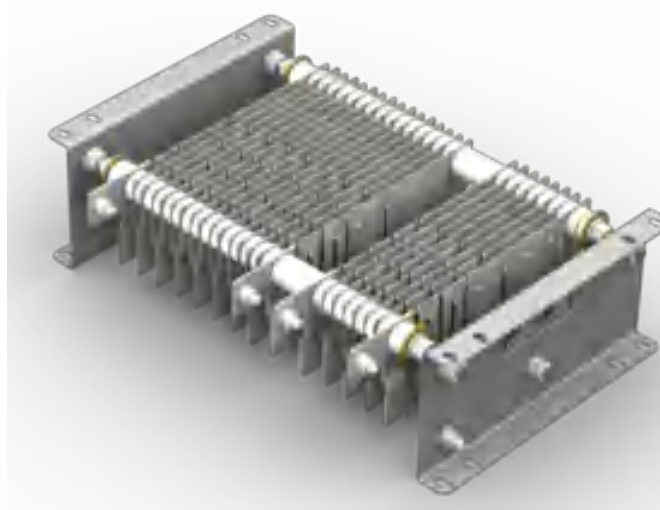
Crowbar resistors are used to suppress transient or short-duration voltage peaks in Traction and Industrial Applications. Crowbar resistors are designed to handle high power loads for limited periods.

Main parameters

Ohmic value

Voltage

Energy



Grid block for crowbar

Starting and Braking Resistors

Starting resistors

Starter resistors are used for wound-rotor induction motors or for squirrel-cage stator motors (normally one step) to limit peak current during starting. The resistor topology can be a three-phase resistor with fixed ohmic value or a multiple three-phase topology with different resistor-value steps.

Main parameters

- Motor power
- Rotor voltage
- Rotor current
- Rotor speed (RPM)
- Type of mechanical load
- Number of steps
- Cycle time (duty cycle)



Brake resistors

Brake resistors are used in many Traction, Marine (e.g. thrusters and winches) and Industrial Drive applications. During braking, power is generated via the electronic inverter and must be dissipated (if not absorbed by the supply) in order to prevent damage to the power electronics. Brake resistor ratings range from a few hundred watts up to several MW and the demands on these resistors are highly application dependent.

Main parameters

- Maximum voltage
- Power and braking duration
- Cycle time (repetition rate)
- Cooling (natural convection, forced-air or liquid-cooled)

Additional parameters

- Electrical connections (size of connection cables, single or multiple conductor)
- Thermal drift; the difference in ohm value of the resistor elements between cold condition and hot condition.
- Ingress protection degree, IP 20/IP21/IP23
- Environment
- Enclosures can be made of galvanized steel DX51D+Z275-M-A-E, mild steel painted in any RAL color or stainless steel types AISI 304 or AISI 316.



Line Test Resistors

Line test resistors for railway applications are used to detect fault conditions on overhead lines (catenaries) before switching on the power. 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) as 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.

Main parameters

Nominal voltage
Test current
Duty cycle



Train Braking Resistors

Braking a train is always 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 train 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 three possible locations for the brake resistors:

- on the roof of the train where the hot air is released upwards
- on the chassis 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
Cooling (forced-air or natural convection)
Dimensions

Railway standards:

- IEC 60322: General scope for resistor design
- IEC 61373: Shock & Vibration Tests
- UNE-EN-50124: Insulation Coordination



Charging and Discharging Resistors

Charging a Capacitor Bank

A DC capacitor bank must be charged in a controlled manner to prevent damage to the rectifier bridge where 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.

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.



Main parameters

- Voltage
- DC link capacitance
- Time constant
- Cycle time

Energizing a Transformer

When a transformer is energized for the first time, a magnetic field must first be established in the core. For the first few cycles, the magnetizing current is limited only by the ohmic resistance and air-cored reactance of the primary winding. As soon as the magnetic field is established, the current decreases to that of the iron-cored reactance. To prevent such high inrush currents, "pre-magnetizing" resistors are inserted in the primary circuit and these are by-passed once the transformer is magnetized. Pre-magnetizing is essential when the energy grid is weak and utility regulations forbid high current peaks taken from the supply.

Main parameters

- Current-time graph
- Ohmic value
- Cycle time



Backer World Wide



North America

Europe

Asia / Oceania

Backer–Facsa Resistor Division

Backer–Facsa S.L. Grid resistors offer solutions for medium to high power in both low and high voltage applications. Their robust construction makes them suitable for many applications in harsh environments where they have proven to be cost-effective and reliable.

Backer–Facsa can tailor resistors to best fit the requirement since different kinds of alloy make it possible to optimally meet practically all application requirements. Standard cabinets and resistor plates are combined to configure resistors at competitive prices while nevertheless allowing customization. Our skilled engineers with years of experience in power resistors, ask you to challenge them with your enquiries!

