




# Power resistors

- > Wind
  - > Neutral grounding
  - > Traction
  - > Harmonic filtering (HVDC)
  - > Starting and stopping
- 



Committed to service

# WE ARE KLK

## New times, new goals, the same enthusiasm

Presenting a new image and new catalogue to our customers is always an exciting challenge. After many years, we have this year made an effort to show you how we have grown over more than 50 years. Staying in a market such as this for so long is synonymous with versatility, quality and service. These 50 years have helped us to consolidate our project in the market: to become a recognised and prestigious manufacturer in the industry, to learn and to develop our products with the help of the best professionals.

Now is the time to thank our customers for continuing to trust us and to keep on improving while giving our best.

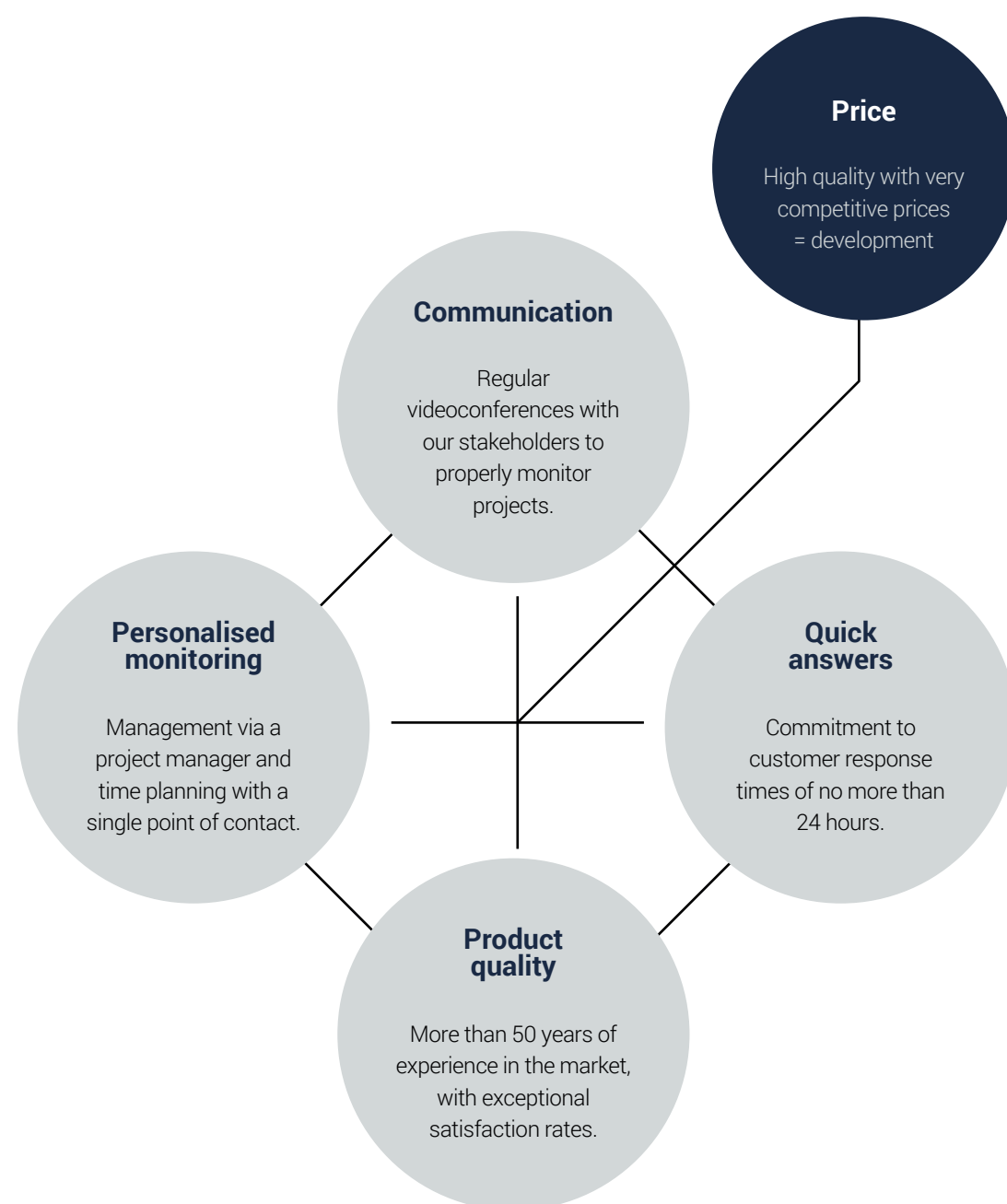
We are KLK, a young 50-year-old company with a long industrial history, with experienced people joined by a new generation of talent eager to go further and with new market ideas, which gives as result the catalogue we are presenting here: a young but seasoned catalogue, sober yet modern, with the primary idea of bringing past, present and future customers closer to our company, with the same quality as always and a customer-centric drive.

Thank you for trusting us

### **Teo Conejero**

Electrical Equipment Product Line  
Resistors  
Head of Worldwide P&L





KLK is an organisation that has always been committed to occupational quality, safety and health. Throughout its history, it has grown based on a process of ongoing improvement in all areas of its business, with particular attention to personal safety, the quality of its accomplishments and environmental protection and conservation.

In this way, we apply quality, health, safety and environmental policies in all the company's activities pursuant to the ISO 9001 and ISO 14001 standards.





## PANDROL

Highly trained teams committed to constant progress and adaptation working together under the commitment that the customer comes first.

### EXCELLENCE THROUGH EXPERIENCE

3,200 people in over 30 countries on five continents contribute to the success of the DELACHAUX Group. The advantages we offer our customers are experience and innovation backed daily through our "multi-local" operations centres.

### LOCAL SOLUTIONS WITH GLOBAL EXPERIENCE

With more than 60 industrial and sales subsidiaries, the DELACHAUX Group works with its customers to provide the best local solutions. This global presence, consisting of a "multi-local" network, allows us to respond quickly to the demands of our markets and to their individual situation, while our customers benefit from our global experience. Lasting relationships with large engineering firms and trans-national industrial groups complement our global vision for our three divisions.

### INNOVATION AT THE SERVICE OF OUR ACTIVITIES

Power resistors is a Group activity framed within the Electrical Equipment product line. This activity allows us to cater to various market segments and offer our customers a range of high-quality products for different uses such as filtering resistors for HVDC, braking resistors for wind power, neutral grounding resistors, traction resistors for railway and load banks.

Established in Gijón, Spain, for more than 50 years this resistor activity has used the Group's full potential through its subsidiaries to reach all corners of the world, offering the high quality and versatility of a local manufacturer but with the financial strength and logistical power furnished by the Delachaux Group, which allows it to undertake all manner of projects worldwide.

The leader in its activities throughout the world, the Railway Infrastructure line engages in the transport of people and goods. This division is the Group's main activity. Its rail fastening systems, rail welding systems and rail track equipment are used in all rail and urban transit networks worldwide. It also offers solutions for controls on the track or rolling stock. Reliability and quality are essential to effectively meeting the needs of demanding markets with rapidly changing technology.

The leader in its activities throughout the world, the "Conductic" line, under the name of CONDUCTIX-WAMPFLER, works in energy and data transmission for all manner of industrial equipment, industrial markets and material lifting and handling.

The leader in its activities throughout the world (high purity chrome), the Metals line, under the name of DCX CHROME, operates primarily in the aerospace and power turbines markets. As the main partner of the superalloy industry (Cobalt-Cr and Nickel-Cr), this division also plays an increasingly important role in the development of renewable energy technologies.

# A STRONG IDENTITY

## "Think globally, act locally"







# GENERAL CONSTRUCTION FEATURES OF NEW RESISTORS



## Features

### - UNALTERABLE

The resistive components of Ni-Cr and Cr-Al alloys are resistant to marine environments and most industrial environments.

### - STABLE OHMIC VALUES

The low values of the temperature coefficients of the high-nickel Ni-Cr alloys and Cr-Al ensure stable ohmic values.

### - HIGH LEVEL OF INSULATION

Mica and ceramic insulated resistors are tested to 70,000 V. Higher voltages are also manufactured on request.

### - QUALITY

The quality system established ensures the compliance of the raw materials in the manufacturing process and of the finished product with the project's technical requirements.

### - CONSTRUCTION

Stamped stainless steel (Cr-Ni, Cr-Al) plates and grills joined by spot welding and spaced with ceramic washers, designed to withstand expansion due to temperature increase. Grills and washers are threaded on mica-insulated studs that support and facilitate the fixing of the resistor to the metal heads.





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Load banks

KLK supplies equipment to the electrical industry sector and railway sector. Founded in 1965, it has fifty years of experience in providing technical solutions to domestic and international customers in the most demanding and competitive markets.

Since 2011 KLK has belonged to the Delachaux Group, a world leader in railway infrastructure, equipment for electrical connections to mobile industrial equipment and the production of chromium metal for the aeronautical sector.





## CROWBAR

This **crowbar** resistor is mainly applied in low-voltage transmission technology through the inverter in wind power generation.

Installed on the rotor side of the wind turbine, it operates as a current transformer on the side of the bypass rotor. When low-voltage disturbances appear in the electricity system, the **crowbar** can prevent DC bus overvoltage and overcurrent in the rotor. Crowbars can dissipate large amounts of energy instantly.

These **crowbars** are designed with very low inductances to be able to handle very high currents in short spaces of time. They are robust resistors designed specifically for each customer since they are mounted in switchgear cabinets where space is usually very limited.



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## CHOPPER

**Chopper** resistors limit the current when the chopper circuit is closed. **Choppers** normally operate at high frequencies to control the AC voltage.

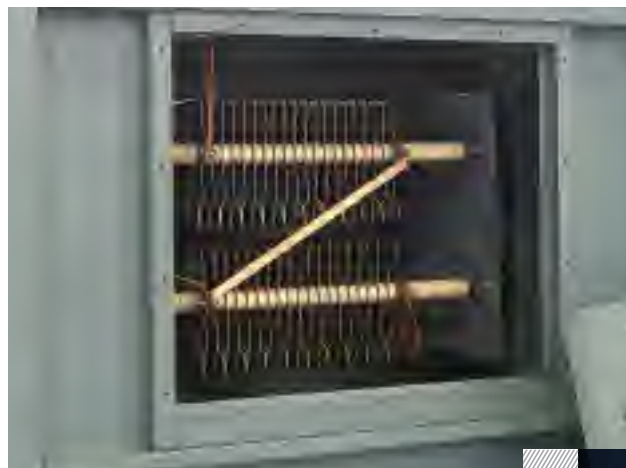
This resistor must be able to work at high voltages and ratios of continuous and repetitive pulsing energy, which means working continuously with high capacities.

A very low parasitic inductance is a mandatory quality in this type of resistor, since the frequency that can be given in the circuit is the KHz range.



These resistors are designed specifically for a growing market from 600KJ to +30MJ and from 72V to +72KV.





Neutral grounding resistors have a number of advantages that have ended up replacing insulated neutral and reactance grounding distribution systems. The most interesting advantages attributed to grounding resistors are:

- Reduction of the short-circuit ground current to values considered suitable in the related electricity distribution project.
- Greater safety of people and machines as no harmful surges occur when opening the related distribution circuit.
- Significant reduction in the number of spurious trippings of the circuit to be protected.
- Ease of troubleshooting.
- Simplicity of operation and maintenance.

The basic design features are aimed at precisely defining the following electrical characteristics:

- Step intensity
- System voltage
- Ohmic value of the resistor
- Connection time

The ohmic value of the resistor is determined based on the step intensity value considered sufficient so that the installed protection devices act reliably and do not reach values which would produce mechanical or electrical failures. Considering the system's voltage divided by (root 3), the initial current is the current circulating through the resistor without the ohmic value being affected by temperature.



The theoretical value of the initial current deemed adequate to achieve all the benefits of the system ranges at around 20% of the three-phase short-circuit current.

The connection time is the time period in which the resistor can be connected to the rated voltage without the resistor overheating. This time is usually set by standards and/or the experience of the project designers.

## CONSTRUCTION

PaT resistors are made up of blocks of resistive stainless steel components with the ideal shape so that the passage of the initial current during the expected connection time does not produce distortion or raise the temperature above the values recommended by the standards.



Reliability and durability in especially harsh environments and robustness against external stresses are the main features of this type of resistor.



KLK has developed its own envelope system, the LIMO\_17 series, which, with only three different models, makes it possible to group different insulation systems and network voltages up to 36kV and a protection class that can reach IP55.

The size of the envelope depends on the level of insulation required and the number of resistor blocks and interior equipment requested by our customers.

Thanks to our LIMO\_17 (Lighting MOdular) modular solution we can offer a high-quality neutral grounding resistor at a very competitive price and in a short period of time.

		Network Voltage				
		<1KV	1KV - 3KV	3KV - 6KV	6KV - 7KV	7KV - 11KV
Defect intensity (Defect time 10 s)	10 A	K1A	K1B	K1C	K1D	K1E
	20 A	K1A	K1G	K2B	K2C	K2D
	50 A	K2A	*	K2G	K2H	K2J
	100 A	K2A	*	K2P	K2Q	K2R
	200 A	K3A	*	*	K3B	K3C
	300 A	K4A	*	*	K4B	K4C
	500 A	K5A	*	*	K5B	K5C
	1000 A	K6A	*	*	K6B	K6C
	1500 A	K7A	*	*	*	*
	2000 A	K8A	*	*	*	*

Key:

KXX + <sup>G</sup>I + IP + Input/Output + <sup>T</sup>I + <sup>TT</sup> + RALXXXX  
                   <sup>M</sup>  
                   <sup>S</sup>
(optional)
(optional)
(optional)

Example:  
 K1C+I+42+CC+TI  
 Resistor for 6 KV voltage network, stainless steel envelope, degree of protection IP43 including intensity transformer.

EQUIPMENT FOR OUR GROUNDING RESISTORS

KLK designs and manufactures grounding resistors required by the customer, which may include the following equipment:

- Vacuum contactor
- Disconnecting switches
- Current transformers
- Voltage transformers
- Heating resistor
- Thermostats
- Power transformers

11KV - 13,8KV	13,8KV - 15KV	15KV - 20KV	20KV - 23KV	23KV - 25KV	25KV - 30KV	>30KV
K1F	*	*	*	*	*	*
K2E	K2F	*	*	*	*	*
K2L	K2M	K2N	*	*	*	*
K2S	K2T	K2V	K2W	*	*	*
K3D	K3E	K3F	K3G	K3H	K3J	*
K4D	K4E	K4F	K4G	K4H	K4J	*
K5D	K5E	K5F	K5G	K5H	K5J	*
K6D	K6E	K6F	K6G	K6H	K6J	*
*	*	K6L	K6M	K6N	K6P	*
*	*	K6Q	K6R	K6S	K6T	*

Legend

G Galvanized  
 I Stainless steel AISI-304  
 M Magnelis ®  
 S Stainless steel AISI-316

Degrees of protection

IP 00  
 IP 13  
 IP 23  
 IP 33  
 IP 43  
 IP 55

Types of Input/Output

C Sealing Gland  
 B Cable Glands  
 P Plug-in terminal

\* Upon request





One of the nearly constant special features when designing high-power resistors is the need to locate them in defined and small spaces, which are almost always impossible to readapt due to the project needs of the machine to be controlled, such as electric traction locomotives. The reduced volume and the particular shape require the implementation of a forced ventilation system and a particular shape of the resistive components.

The heat exchange between the resistive components and the surrounding air can be increased by supplying air at room temperature, which will accelerate the movement of hot air and achieve a higher volume of cold air in contact with the resistive components per time unit and, therefore, a greater amount of heat removed.

This technique, along with the installation of the resistors in suitably selected compartments, allows for traction resistors to work at higher temperatures than standard resistors. The operating temperature of the resistive material selected is up to 1000°C. High temperatures require meticulous care in the selection of insulating materials that directly support the resistive components - insulating elements that must endure strong and ongoing thermal shocks. In addition, since the equipment may be in direct contact with the environment, the chosen insulation will have a low moisture absorption value.

The resistors installed in motor vehicles are exposed to vibrations of variable amplitude and frequency. KLK, in its resistor project, takes into account the vibration and shock demands pursuant to international standards.



## TESTING

Pursuant to international standards, high-power resistors connected in the power circuits of motor vehicles are subject to the following tests: type testing and series testing.

### TYPE TESTING:

As required by our design and manufacturing philosophy, KLK, prior to making the definitive series, builds a prototype on which exhaustive heating, vibration and shock testing is performed pursuant to standard CE I332 to confirm that the real working conditions perfectly meet the conditions agreed with our customers. The following tests may be performed on an optional basis: Hygroscopic-short-circuit and performance under rain.

### SERIES TESTING:

These tests are performed on every resistor manufactured by KLK and involve:

- Ohmic value measurement
- Dielectric strength test
- Final check of finishing: measures, painting, appearance, etc.



Our traction resistors are adapted to the most demanding international standards to comply with the most stringent requirements for insulation, stress, vibration and environmental conditions.



High voltage direct current (HVDC) is a technology developed over 50 years ago to increase the efficiency of power transmission over long distances.

## Background and technology

Power plants generate alternating current (AC) and most power lines carry AC that oscillates with 50 or 60 cycles per second, for either the high-, medium- or low-voltage distribution network. Electricity also reaches consumers in homes, industries and offices as AC.

Direct current does not oscillate, resulting in lower energy losses during transmission by DC. The current is transformed at a converter station (KLK RESISTENCIAS HVDC) and is transmitted to the receiving point by overhead lines or cables. It is then reset to AC at another converter station (KLK RESISTENCIAS HVDC) and injected into the receiving AC network.

## HVDC and energy efficiency

El sistema HVDC es atractivo porque se pierde menos electricidad en la transmisión que con la tecnología de CA convencional. También requiere menos líneas de transmisión, lo que significa que se necesita menos superficie de terreno. Debido a que se necesita equipo especial para convertir la electricidad de corriente alterna a corriente continua, el HVDC es más barato sólo a distancias largas, típicamente más de 600 kilómetros (373 millas) para líneas aéreas y más de 50 km para cables submarinos.



An HVDC system is attractive because less electricity is lost in transmission than with conventional AC technology. It also requires fewer transmission lines, meaning that less land area is required. Since special equipment is needed to convert AC electricity to direct current, HVDC is cheaper only over long distances, typically more than 600 kilometres (373 miles) for overhead lines and more than 50 km for underwater cables.

Long-distance transmission demand is increasing due to the growing energy needs of developing countries and the efforts to tap more renewable energy sources. While non-renewable energy sources such as coal, oil and gas can be transported and used when energy is needed, hydropower, wind power, solar power and tidal power can only be transmitted as electricity. In addition, the major renewable energy sources tend to be located far from urban and industrial centres, where electricity is used.

Another added advantage of HVDC is that it can be used to connect different AC networks and increase the efficiency of each. It can compensate for fluctuations in the flow of energy, making it the ideal solution for linking wind farms whose uneven production could otherwise disrupt the reliability of the network.



Our traction resistors are adapted to the most demanding international standards to comply with the most stringent requirements for insulation, stress, vibration and environmental conditions.





Static compensators (SVC) improve power transmission, distribution performance and the control of reactive power.

- A harmonic filter consists of 2/3 components: Capacitors, inductors and resistors.
- Inductors and capacitors enable harmonic currents to be deflected towards the resistor, where they are dissipated safely.

In HVDC, converter stations are contaminated by numerous harmonic distortions, which then must be filtered (AC/DC filtering).

- When the HVDC VSC station is energised, the pre-insertion resistor limits the load current of the capacitors and cable.
- When the station stops, the DC cable remains charged (high capacity) and electricity must be evacuated in a resistor.
- When the HVDC is connected to wind farms, in the event that the AC network is defective and cannot receive capacity, the wind turbines must be stopped. Resistors -choppers in this case, must be used in this case (braking resistors).

Our experienced team of engineers works with the customer so they can design the best solution for the different characteristics required depending on the solution that our customer seeks to offer and the proposed environmental conditions. KLK offers a tailored solution of HVDC filtering resistors.

Our R&D department continues to implement new solutions both in the active part as in envelopes and insulation, so that we are right now one of the worldwide leaders offering a high-quality, reliable and price-conscious solution in the world of resistors for HVDC projects. Working with market leaders year after year supports this effort, in which KLK invests annually and which has led us to this position.

## TESTING

### SERIES TESTING:

These tests are performed on every resistor manufactured by KLK and involve:

- Verification of ohmic value
- Dielectric strength testing in individual resistor blocks
- Dielectric strength test in the general frame
- Measurement of insulation resistance
- Measurement of inductive value across the frequency spectrum

### TYPE TESTING:

Tests are conducted exclusively on manufacturing prototypes and are basically:

- Heating tests on a single rack
- Basic insulation level testing
- Theoretical modal spectral seismic study
- Verification of the degree of protection



Our equipment is designed with low inductances to work efficiently at high frequencies and are highly resistant to seismic stresses and corrosive environments.

TALCHER. East-South Interconnector I. 2001

**SIEMENS**

India

Type: HVDC Resistors. 500 kV. 2000 MW

TALCHER. East-South Interconnector I. 2001

**SIEMENS**

India

Type: HVDC Resistors. 500 kV. 2000 MW

ALSVC Ittefaq. 2003.

**SIEMENS**

Arabia Saudi

Type: Filtration Resistors

KOLAR. East-South Interconnector II. 2006

**SIEMENS**

India

Type: HVDC Resistors. 500 kV. 2000 MW

KOLAR. East-South Interconnector II. 2006

**SIEMENS**

India

Type: HVDC Resistors. 500 kV. 2000 MW

ETHKE. Interconnection HVDC. 2017

**SIEMENS**

Ethiopia – Kenya

Type: Filter Resistors

BD2. Interconnection HVDC. 2017

**SIEMENS**

India – Bangladesh

Type: Filter Resistors



# WE ARE LEADERS IN FILTER RESISTORS FOR HVDC







### SLIP-RING MOTORS

This type of motor is still used for high-power and high-voltage applications for use in severe conditions requiring high reliability and robustness, without electronics (cement plants, mining, pumping stations). Starting resistors are designed specifically for each circumstance, thereby enabling a phased and smooth engine start.

### SQUIRREL CAGE MOTORS

Rotor resistors allow for a voltage drop during start-up, thus reducing by up to three times the starting point and reducing stress on it.

### CRANE RESISTORS

A large number of port authorities and steel mills still rely on this equipment due to the ease of replacement, when facing the impossibility of a prolonged stoppage and the strength and durability of this equipment.

### STOPPING RESISTORS

A running engine involves a large amount of kinetic energy during braking and this energy must be returned to the network or dissipated as heat. The resistors manufactured by KLK provide a compact and economical system to remove this unwanted energy. Capacity can range from 0.15 KW and up to 1.5 MW in various applications (ship cable reels, traction equipment braking, either on locomotive or at the end of the track connection).



Robust, reliable and highly efficient. These are the main features of our family of load banks, which can be manufactured following special customer requirements.

Load banks are used for the proper maintenance and operation of accumulator batteries that, due to service needs, must be discharged and recharged following a cycle based on the needs of the related facility.

Load resistors are highly versatile in electrical engineering laboratories, in engine test benches, etc. The carefully studied layout of the resistor blocks in the general frame allows for multiple combinations of ohmic values and intensity through simple manipulations in the connections located on terminal board.

Applicable as well in generator sets, load resistors are necessary to avoid the known problems of low-power diesel engines.



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