

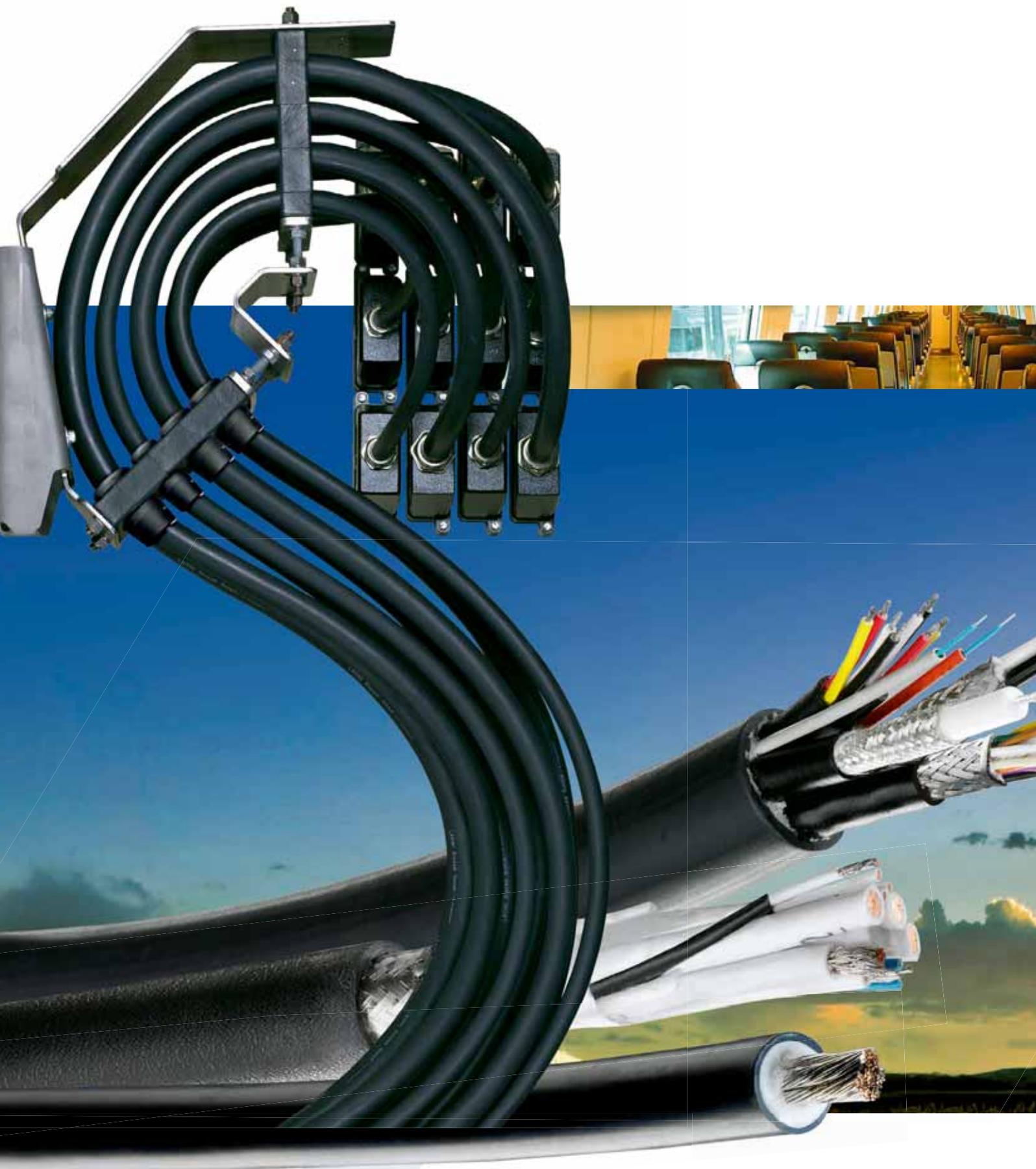


High-tech cables & systems for rolling stock applications

Rolling Stock

The Quality Connection

LEONI



Contents

High-tech cables & system solutions	4
Solutions for complex requirements	5

Engineering & Support

Comprehensive competence for your core business	6
Process-accompanying support	8

Wires & Strands

Earthing straps and connection leads	10
--------------------------------------	----

Cables

Practice-oriented cable solutions according to international standards	12
Product features that stand for safety, cost advantages and high user benefit	13
BETAtrans® GKW	14
BETAtrans® GKW FE 180	15
BETAtrans® DATA C-flex	16
BETAtherm® ENgine / BETAflam® ENgine	18
UIC train cables and train bus cables	19

Special cables

Customer-specific special cables for rolling stock	20
Application-specific cable solutions	21
– Highly flexible power and supply cables	
– Highly flexible hybrid cables	
– Optical fibre (POF & glass fibre cables)	

Cable systems

Engineering services	22
Feasibility and concept studies	23
Inter-car jumper systems	24
High voltage roof jumpers	26
Build-to-Print / Refurbishment	27

Worldwide presence	28
References	28
The LEONI Group	29
Green Technology	30



Issue September 2014

We reserve the right to make technical modifications, typographical errors and mistakes.

High-tech cables & system solutions



LEONI is a worldwide leading provider of standard and customised specialist cables as well as pre-fabricated cable systems. With our Business Unit Transportation, Rolling Stock division, we provide our customers with all the expertise of a global enterprise, focused on the needs of the transportation industry.

With our extensive product and service portfolio for the internal and external cabling of rolling stock, we accompany you over the entire life cycle of your vehicles – worldwide.

As a strong partner, we offer you application-specific cables and cable system solutions according to national and international standards. In the process, you can rely on our well-established industry and product knowledge and our long-time experience.

Quality – Reliability – Safety

Our fields of competence

- High-speed trains
- Regional commuter trains
- Locomotives
- Trams
- Underground trains
- Freight trains
- Passenger carriages
- Commuter and multi-unit coaches
- O-buses



Solutions for complex requirements

LEONI offers you a comprehensive product spectrum which corresponds to the complex requirements in terms of both breadth and depth.



The LEONI value added chain



Anyone with the task of producing cables for rolling stock must have a wide range of technical disciplines and a broad product range at their disposal. The requirements are both technically demanding and very complex. On the one hand, numerous extremely diverse products are required and on the other hand, the most extreme operating conditions and difficult installation conditions must be taken into account. LEONI is one of the few cable manufacturers and system providers that can satisfy all these requirements.

This is made possible thanks to the unique LEONI value added chain, which extends from thin copper wire to multi-strand special cables to installation-ready cable systems. All cable components and products are developed and manufactured in-house. This guaranteed optimally matched solutions. We offer you earthing straps, standard cables according to national and international standards, application-specific special cables, connection-ready packaged cables, subsystems and complete system solutions for rail-bound vehicles such as high-speed trains, locomotives, trams, underground and passenger carriages.

Our product portfolio

- Electron-beam cross-linked cables and wires
- Halogen free cables
- Cables with circuit integrity
- Weight and volume-optimised cables
- Heat and cold-resistant cables
- Optical fibre cables (fibre optics)
- Power and supply cables
- Control cables
- Bus lines (Ethernet, MVB and WTB)
- UIC-railway cables and train bus lines
- Data and coaxial cables
- Hybrid cables and special designs
- Earthing straps, earthing circuits
- Spiral cables
- Cable harnesses
- Rolling stock jumper systems

Areas of application

- Communication links
- Infotainment
- Seat wiring
- Engineer panel wiring
- Radio communicator (spiral cables)
- Drive systems
- Motor connection cables
- Switch cabinet and switch panel wiring
- Heating, ventilation and air conditioning systems
- Sensor and component connections
- Brake systems
- Door and running board controls
- Rolling stock jumpers
- High voltage roof jumpers
- Train safety systems
- Train radar

Comprehensive competence for your core business

Product development

Concept + development

Test + simulation

Process-accompanying support

When you consistently focus on your core business, you arrive at better solutions faster and more efficiently.

You benefit from our support services and technologies and can concentrate on your core business.

Concept + development

- On-site consultation
- One-stop shop for customer-specific and standardised solutions
- Development of new materials for cables with special operating conditions
- Development of system solutions based on specified interfaces
- Arrangement and dimensioning of custom cable solutions
- Concept development and rolling stock jumper solutions already in the development phase for new vehicle platforms
- Construction of mechanical connections of rolling stock jumper systems
- Exact longitudinal arrangement in the moving area corresponding to the specific profile
- Calculation of maintenance and operating costs over the entire life cycle (life cycle costs) of rolling stock jumper systems
- Design to cost

Test + simulation

- Prototype construction under close-to-production conditions
- Design and implementation of individual and integration tests
- Determination of optimisation potential
- Design and construction of special testing devices for system endurance tests for verification of the planned service life
- Testing devices for the layout testing of moving cable systems
- Engineering-based service life calculations using load models
- Finite element calculations for cable suspension and guidance systems
- Climate and service life tests for cables, system components and cable systems
- In-house fire test laboratory



Implementation



Production

- The latest production technologies, from prototype to customer-specific serial production
- Production of application-specific and market-specific standard and special cables
- Cutting, stripping and attaching (with automatic assembly units)
- Soldering
- Crimping (with automatic assembly units)
- IDC (cutting/clamping technology)
- EMC compliant assembly
- Installation of electronic and mechanical components
- Installation of complete assemblies/systems, incl. steel sheet and plastic parts
- Production of injection-moulded plastic parts
- Extrusion of cables (plugs, grommets)
- Global production and service presence according to the needs of your value added concept

Installation + logistics

- Customer-specific logistics solutions (just in time)
- Installation outsourcing
e. g. technical support for installation of rolling stock jumper systems and training of the assembly and maintenance personnel

After sales

- Spare parts management for components and systems for up to 20 years
- Retrofit partner for the modernisation of systems in existing railway vehicles

Process-accompanying support



Project management made by LEONI handles the majority of your work, provides planning assurances and ensures that you can concentrate fully on your core business.

Project management

...for efficient solutions worldwide

Complex projects require clear structures and processes. We define the project goals together with our customers in consideration of the specified time and cost framework and the available resources. With international projects, in particular, it is essential to harmonise the most diverse technical, economic, cultural, legal and political influences. Here we bring our experience gathered in countless international projects. Once they have been established, we assure compliance with the individual steps and the realisation of the overall project.

...while keeping an eye on the big picture

Highly qualified, internationally-experienced project managers with interdisciplinary and intercultural qualifications plan and coordinate all work packages related to electrical connection technology for your overall project with respect to quality, costs and time – worldwide. In the process, we use the latest communications and project management tools, which also correspond with our customer's IT environment.

In our project management, all phases of development, production and installation of cable systems for railway vehicles are incorporated, particularly

- planning and implementation of development services over all review and verification stages
- prototype creation and initial sample testing with the customer
- consultation and support with the installation of the initial components delivered to the customer.



Technologically leading

LEONI has established a worldwide leading position with its products. LEONI combines its entire know-how specially in the area of rolling stock technology to create a perfect ensemble, which hardly any other cable manufacturer can offer. In addition, LEONI continuously invests in new technologies, systems and processes and even develops machinery and processes for the production and testing of cables and cable system solutions as necessary.

An excellent example is the electron-beam cross-linking of plastics (BETA technology). With this technology, highly accelerated electrons penetrate into the insulation material of cables and cross-link the polymer chains of the plastic on a three-dimensional level. As a result, the insulation and thus the entire cable has significantly higher thermal and chemical resistance.



Earthing straps and connection leads



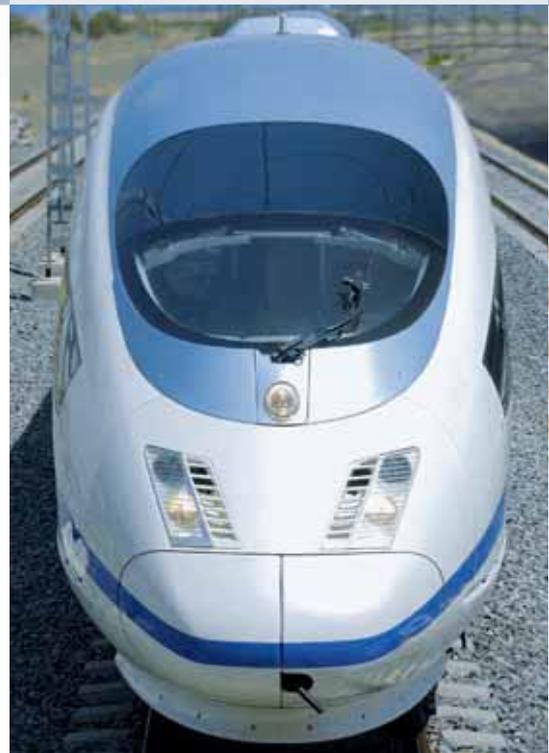
Ranges of application

- Switch and control cabinets
- Cable trays
- Roof superstructures
- Under-floor components

If required, we can also provide the earthing straps and current leads with special insulation or with strain relief.

We produce flexible and highly flexible earthing straps and current leads for both protective earthing in the interior of the railway vehicle and in the under-floor or exterior area of the vehicle. In the process, you choose between standardised or tailored solutions in the widest variety of designs – flexible or highly flexible, as metre goods or assembled and ready for connection.

Our product assortment also offers copper flexibles, round and square mesh and fibre ribbons made of the widest range of materials with and without surface refinement in conductor cross-sections from 0.5 to 1000 mm² in observance of relevant standards.



Highly-flexible copper flexibles

based on DIN 46438

Materials

E-Cu/OF-Cu and Cu alloys, bare,
tin-plated, nickel-plated or silver-plated

Flat-rolled fibre ribbons, highly flexible

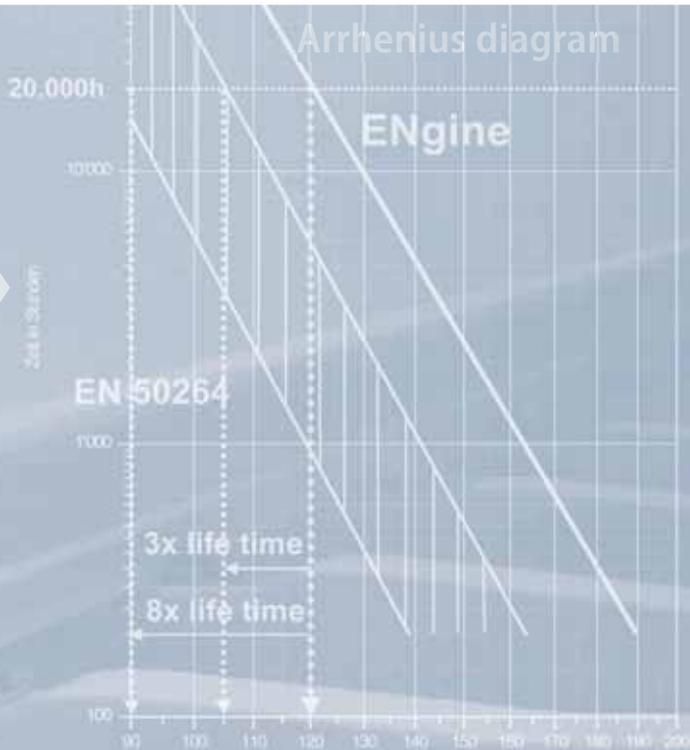
based on DIN 46444

Materials

E-Cu, bare, tin-plated, nickel-plated or silver-plated



Practice-oriented cable solutions according to international standards



Ranges of application

- Cable systems
- Switch panels and selector blocks
- Control panels
- Cable ducts and harnesses
- Engineer's cabins
- Resistance and brake blocks
- Energy and signal cables for DC and AC voltage
- Inverters
- Main power and battery cables
- Communications systems (ORMR, PIS)
- Monitoring and recording systems (CCTV)

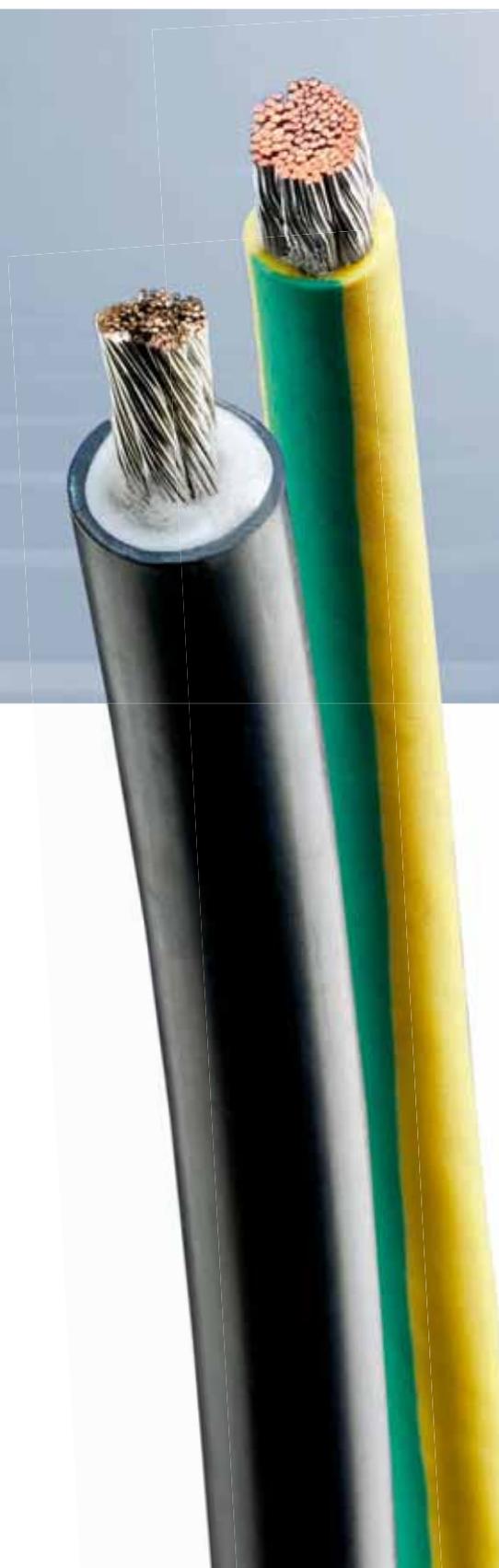
With each new generation of vehicles, the requirements on system availability and the equipment level of electrical and electronic assemblies for power distribution, data transmission and control increase. The absolute safety and reliability of the connection technology is prerequisite.

LEONI railway cables are used for protected installation in indoor and outdoor areas of railway vehicles, buses and other transport means. This is especially true in places where optimal adaptability and installation friendliness are demanded and the cable volume plays a crucial role.

The LEONI **BETAtrans® GKW**, **BETAtherm® Engine** and **BETAflam® Engine** product groups stand for a comprehensive product portfolio which meets the highest requirements of manufacturers of railway vehicles. LEONI offers single and multi-core control cables, auxiliary operating and main power cables as well as data bus and coaxial cables.



Product features that stand for safety, cost advantages and high user benefit



Safety

All railway cables are non-fire-propagating, have low smoke density and are halogen-free. In the event of a fire, no corrosive gases are released, and the railway cable has a low toxicity index. With the low fire load density, the combustion heat is reduced to a minimum.

Long service life under extreme conditions

Thanks to its high media resistance (oils, fuels, alkalis and acids), UV and ozone resistance and abrasion resistance, LEONI railway cable can withstand even the most extreme atmospheric influences and installation conditions. Depending on the cable type and standard, the temperature resistance lies between -40°C and $+120^{\circ}\text{C}$, with **BETAtans® GKW** between -55°C and $+120^{\circ}\text{C}$. An additional important feature is the corona and partial discharge resistance with high electrical loads during operation.

Space-saving

Similar to automotive construction, the space available for the installation and laying of cables is becoming increasingly cramped due to the increasing number of electrical and electronic systems. LEONI's weight-optimised cable contributes to the solution of this problem. Despite thin insulation wall thicknesses and reduced outer diameters they have very good dielectric properties without diminished safety and reliability. This is due in particular to their electron-beam cross-linked insulation materials.

Data transmission security

Increasingly more communication systems and electrical signals in trains and locomotives increase the risk of mutual electromagnetic interference. With the use of various shielding techniques and special materials, we give our cable solutions optimal EMC properties. As a result, signal, control and energy cables from LEONI can be installed in even the tightest space without the risk of mutual interference.



BETAtrans® GWK

Control and installation cables product portfolio



Product program overview

BETAtrans® GWK R	600/1000 V "thin wall", single-core, conductor cross-section 0.5 - 2.5 mm ²
BETAtrans® GWK flex R	600/1000 V "thin wall", multi-core
BETAtrans® GWK C-flex R	600/1000 V "thin wall", multi-core, EMC-optimised shielding
BETAtrans® 3 GWK	600/1000 V single-core, conductor cross-section 0.5 - 400 mm ²
BETAtrans® 3 GWK flex	600 / 1000 V multi-core
BETAtrans® 3 GWK C-flex	600/1000 V multi-core, EMC-optimised shielding
BETAtrans® 4 GWK-AXplus	1.8 / 3 kV single-core, conductor cross-section 1 - 400 mm ²
BETAtrans® 4 GWK-AXplus flex	1.8 / 3 kV multi-core
BETAtrans® 4 GWK-AXplus C-flex	1.8 / 3 kV single-core and multi-core, EMC-optimised shielding
BETAtrans® 9 GWK-AXplus	3.6 / 6 kV single-core, conductor cross-section 1.5 - 400 mm ²
BETAtrans® 9 GWK-AXplus flex	3.6 / 6 kV multi-core
BETAtrans® 9 GWK-AXplus C-flex	3.6 / 6 kV single-core and multi-core, EMC-optimised shielding

BENEFITS for OEMs and operators

- **Temperature index +120 °C (20,000 h at 50 % residual elongation)** allows a ≥ 25 % higher current rating and increases the service life to three to four times that of conventional cables
- **Temperature resistance down to -55 °C** guarantees a longer service life in cold ambient temperatures, because embrittlement and materials damage already appear in conventional cables at -10 °C
- **Excellent corona resistance** with high-frequency spikes for best performance in critical applications, such as in inverters, reduces material fatigue in the cable insulation
- **Constantly high partial discharge resistance** thanks to highly-developed materials and SRC technology (Special Round Conductor)
- **Weight-reduced railway cable** lowers energy costs during the entire operating phase of the railway vehicle
- **The smallest insulation and cable diameters** with BETA irradiation process – resulting in a reduced spatial requirement and lower consumption of installation material, such as cable screw couplings and guides
- **No chemically actuated cross-linking agents** thanks to physical BETA technology (chemically cross-linked cables are subjected to higher temperatures and an additional accelerated ageing)
- **Compressive strength** even at extremely high temperatures
- **Short-circuit-proof** with electrical defects (e.g. with extended overload current)
- **Low diameter tolerances** and consistent insulation wall thickness enable fault-free insulation removal and thus faster assembly and waste reduction

BETAtrans® GKW FE 180

Control and installation cables product portfolio



BENEFITS for OEMs and operators

- 180-minute fire resistance in accordance with BS 6387 and guaranteed circuit integrity with full rated voltage U₀ and U
- Conformity with IEC and EN fire resistance standards

Of course, FE versions also offer all the benefits of Standard BETAtrans®-GKW cables (see page 14).

Product program overview

BETAtrans® GKW RI FE180	300 / 500 V, single-core
BETAtrans® GKW RI FE180 flex	300 / 500 V, multi-core
BETAtrans® GKW RI FE180 C-flex	300 / 500 V, multi-core, EMC-optimised shielding
BETAtrans® 3 GKW FE180	600 / 1000 V, single-core, conductor cross-section 0.5 - 400 mm ²
BETAtrans® 3 GKW FE180 flex	600 / 1000 V, multi-core
BETAtrans® 3 GKW FE180 C-flex	600 / 1000 V, multi-core, EMC-optimised shielding
BETAtrans® 4 GKW-AXplus FE180	1.8 / 3 kV, single-core, conductor cross-section 1 - 400 mm ²

BETAtrans® GKW and BETAtrans® GKW FE 180 fire protection properties in accordance with corresponding standards

Standard	Fire protection levels inside of vehicles	Fire protection levels outside of vehicles
EN 45545-2	HL1-HL3	HL1-HL3
EN 50264-1		
BS 6853	Ia, Ib, II	Ia, Ib, II
DIN 5510-2	1, 2, 3, 4	1, 2, 3, 4
NF F 16-101	A1, A2, B	A1, A2, B
NFPA 130		
PN-K-O2511		
UNI CEI 11170-3	LR1-LR4	LR1-LR4
GOST R	53315	
BCA	200009266/7/8/9	

Additional fire protection features

BETAtrans® GKW FE 180

B5 6387	Fire resistance for 180 min. Cat. A
	Fire resistance with mechanical impact for 15 min. Cat. X
IEC 60331-11/21	Fire resistance for 180 min.
EN 50200	Fire resistance with mechanical impact on cables with low Ø, with unprotected installation for 120 min.

BETAtans® DATA C-flex

Data bus and video cables product portfolio



BENEFITS for OEMs and operators

- **Low-loss data transmission >10 Gbit/s**
- **Halogen free insulation and jacket**
- **Improved behaviour in case of fire** thanks to outstanding materials BETAtans DATA cables comply with all important fire protection standards for rail applications
- **Environmental and chemical resistance** thanks to electron-beam cross-linking
- **Compact assembly** resulting in reduced spatial requirement and low consumption of installation materials, such as cable screw couplings and guides
- **Temperature resistance down to -40°C**
- **Longer operating times** and fewer defects with an environmentally compatible production process
- **Increased mechanical resistance** thanks to cross-linked insulation in standard versions
- **Outstanding NEXT – low attenuation, low skew for data transmission in the high-frequency range** thanks to excellent shield properties
- BETAtans DATA C-flex MVB and WTB cables comply with UIC 558 requirements and can be used **for the connection of stationary and occasionally moved parts**
- BETAtans DATA Ethernet cable complies with requirements according to EN 50288 and IEC 61156 for categories 5,6,7 and 7A and are **suitable for data and video transmission with bandwidths up to 1200 MHz**
- **Colour version** on request

Product program overview

BETAtrans® DATA C-flex 120 Ω MVB
Multifunction vehicle bus cable
BETAtrans® DATA C-flex 120 Ω MVB FOAM
Multifunction vehicle bus cable
BETAtrans® DATA C-flex 120 Ω WTb
Wire train bus cable
BETAtrans® DATA C-flex 120 Ω WTb FOAM
Multifunction vehicle bus cable
BETAtrans® DATA C-flex 120 Ω WTb FE 180
Multifunction vehicle bus cable with circuit integrity
BETAtrans® DATA C-flex 100 Ω CAT 5/5e
Ethernet and data bus cable
BETAtrans® DATA C-flex 100 Ω CAT 5/5e FOAM
Ethernet and data bus cable
BETAtrans® DATA C-flex 100 Ω CAT 5/5e FE 90
Ethernet and data bus cable with circuit integrity
BETAtrans® DATA C-flex 100 Ω GigaCAT 6 FOAM
video cable
BETAtrans® DATA C-flex 100 Ω GigaCAT 7 FOAM
Fixed Ethernet, data bus and video cable
BETAtrans® DATA C-flex R 100 Ω GigaCAT 7A FOAM
Fixed Ethernet, data bus and video cable
BETAtrans® DATA C-flex 100 Ω GigaCAT 5/5e s FOAM
Fast Ethernet, data bus and video cable with silver-plated strands
BETAtrans® DATA C-flex 100 Ω GigaCAT 7 s FOAM
Fixed Ethernet, data bus and video cable with silver-plated strands
BETAtrans® DATA C-flex 100 Ω GigaCAT 7A s FOAM
Fast Ethernet, data bus and video cable with silver-plated strands

BETAtrans® DATA and BETAtrans® DATA FE 90/180 fire protection properties in accordance with corresponding standards

Standard	Fire protection levels inside of vehicles	Fire protection levels outside of vehicles
EN 45545-2	HL1-HL3	HL1-HL3
EN 50306-1		
BS 6853	Ia, Ib, II	Ia, Ib, II
DIN 5510-2	1, 2, 3, 4	1, 2, 3, 4
NF F 16-101	A1, A2, B	A1, A2, B
NFPA 130		
PN-K-02511		
UNI CEI 11170-3	LR1-LR4	LR1-LR4
GOST R	53315	

Additional

BETAtrans® DATA FE 90/180 fire protection properties

IEC 60331-11/21	Fire resistance for 180 min.
-----------------	------------------------------

BETAtherm® ENgine and BETAflam® ENgine

Control and installation cables product portfolio



Product program overview

BETAtherm® ENgine EN 50306-2	300 / 500 V* "thin wall", single core conductor cross-section 0.5 - 2.5 mm ²
BETAflam® ENgine EN 50306-4	300 / 500 V* "thin wall", multi-core, unshielded or with EMC-optimised shielding
BETAtherm® ENgine EN 50264-3-1	600 / 1000 V, single-core, conductor cross-section 0.5 - 400 mm ²
BETAflam® ENgine EN 50264-3-2	600 / 1000 V, multi-core, unshielded or with EMC-optimised shielding
BETAtherm® ENgine EN 50264-3-1	1.8 / 3 kV, single-core, conductor cross-section 1 - 400 mm ²
BETAtherm® ENgine EN 50264-3-1	3.6 / 6 kV, single-core, conductor cross-section 1.5 - 400 mm ²
* 600 / 1000 V no standard requirement, however available on request	

BENEFITS for OEMs and operators

- **Temperature index +120 °C (20,000 h at 50 % residual elongation)** allows a ≥ 25 % higher current rating and increases the service life to three to four times that of chemically cross-linked cables
- **Temperature resistance down to -40 °C**
- **Excellent corona resistance** with high-frequency spikes for best performance in critical applications, such as in inverters, reduces material fatigue in the cable insulation
- **No chemical cross-linking agents** thanks to physical BETA technology (chemically cross-linked cables are subjected to higher temperatures and an additional accelerated ageing)
- **Longer operating times** and fewer defects with an environmentally compatible production process
- **Purer, more homogeneous materials;** no cross-linking of chemically cross-linked substances in the extrusion process
- **Outstanding flame resistance** with high LOI values

Classification

EN 50306-2 300V* M	EN 50306-4 5P 300V* MM 105
EN 50306-4 1E 300V* MM 105	EN 50264-3-1 600V M
EN 50306-4 1P 300V MM 105	EN 50264-3-2 600V MM S
EN 50306-4 3E 300V* MM 105	EN 50264-3-2 600V MM S
EN 50306-4 3P 300V* MM 105	EN 50264-3-1 1800V M
EN 50306-4 5E 300V* MM 105	EN 50264-3-1 3600V MM

* 600 / 1000 V no standard requirement, however available on request

- **Reduced flame propagation**
- **Constantly high partial discharge resistance** thanks to highly developed materials
- **Complies with requirements according to EN 45545-2**

UIC-railway cables and train bus lines

Product portfolio for flexible applications



Product program overview

UIC connection cable	18-cores	
UIC through circuit	16-cores	
UIC through circuit	16-cores	with system integrity
UIC single four-cores	4-cores	
UIC bus line (WTB)	2-cores	120 Ω
EP control conductor	9-cores	
EP control conductor	10-cores	
UIC connection cable	12-cores	
MVB train bus line	2-cores	120 Ω
MVB train bus line	3-cores	120 Ω
MVB train bus line	8-cores	120 Ω



BENEFITS for OEMs and operators

- Halogen free and non-fire-propagating
- Low smoke density and corrosion in case of fire
- UV and ozone resistant
- Heat pressure resistant and abrasion resistant
- Oil, acid and alkali resistant
- Resistance to cold

LEONI UIC cables are developed and produced according to UIC specifications. They offer ideal conditions for use as connecting conductors between carriages and as through conductors or direct lines within carriages.

The cables transmit analogue and digital signals, e.g.

- for voice connection of train personnel
- remote control of train components (e.g. doors)
- for power distribution and control of electropneumatic brakes

The rough ambient condition in railway operation were given special consideration in the construction of these cables. In the coupling area, in particular, only high-quality special materials provide a safe solution.

Customer-specific special cables for rolling stock

Design features include

- Use of highly flexible copper strands, classes 5 and 6 according to DIN EN 60228 / VDE 0295
- High tensile strength with integrated Kevlar® supporting web
- Thin-wall versions
- Halogen-free according to DIN VDE 0472-815 / EN 50267-2-1
- Non-fire-propagating according to DIN 50265-2-1 / IEC 60332-1, as well to DIN 50266-2 / IEC 60332-3
- Ozone resistance according to EN 50305 Section 7.42
- Temperature range from -30 °C to +100 °C
- Low smoke density
- Low fire load
- Low toxicity
- Weather resistant
- Designed for easy insulation and jacket removal
- Resistant to acids and alkalis
- Resistant to oil and fuel

Details often make the difference in the performance and safety of a cable. Special cable solutions from LEONI are exactly attuned to your application for optimal functionality, regardless of whether it is a flexible or stationary application.

The individual cable design and the use of specially developed sheath and insulation materials enables high thermal and mechanical resistance. LEONI specialcable solutions are produced according to national and international standards for the railway industry.

Our additional services

- Production of short lengths (starting at 100m of cable)
- Prototype cables
- Realisation of cable design
- Finished cable within a few weeks
- Patented solutions for energy cables with high currents with higher frequencies up to square current flow (skin effect and EMC-optimised)

Application-specific cable solutions

Highly flexible power and supply cables

- Cross-section range up to 400 mm²
- Single-wire or multi-core
- With/without Cu braided shield
- Arrangement for all common cable ratings
(300/500 V · 0.6/1 kV · 1.8/3 kV · 3.6/6 kV)

For applications subject to high mechanical stress
(e.g. in LEONI rolling stock jumper system)

Highly flexible hybrid cables

- Application-specific combination of power and signal transmission as well as data and bus lines in one cable (WTB, MVB, coaxial cables, Ethernet)
- Hybrid cable made of a combination of metallic conductors and individual optical fibres or even complete optical fibre cables (e.g. application-specific rolling stock jumper cables)
- For applications subject to high mechanical stress
(e.g. in LEONI rolling stock jumper systems)



Optical fibre (POF & glass fibre)

Optical fibre on glass or synthetic basis (POF = Polymer Optical Fibre) assures a safe and disruption-free transmission of signals and thus data, images and, if applicable, even light for the lighting. Optical fibre conductors are distinguished by

- high data transmission rates with extensive reserves
- EMC compliance – electromagnetic disturbances have no influence on the transmission properties
- galvanic separation – no potential equalisation necessary
- low weight with the smallest dimensions

Due to their special features, optical fibre is used in rolling stock technology wherever fast and disturbance-free communication must take place, such as in the engineer and control link.



LEONI offers two type of optical fibre cables:

- Optical fibre cables made of glass or synthetic fibres (halogen-free and non-fire-propagating according to IEC 60332-1 and IEC 60332-3)
- Optical fibre cable are also available in customer-specific hybrid cables

Engineering services



Ranges of application

- Feasibility and concept studies
- Rolling stock jumper systems
- High voltage roof jumpers
- Build to print
- Refurbishment



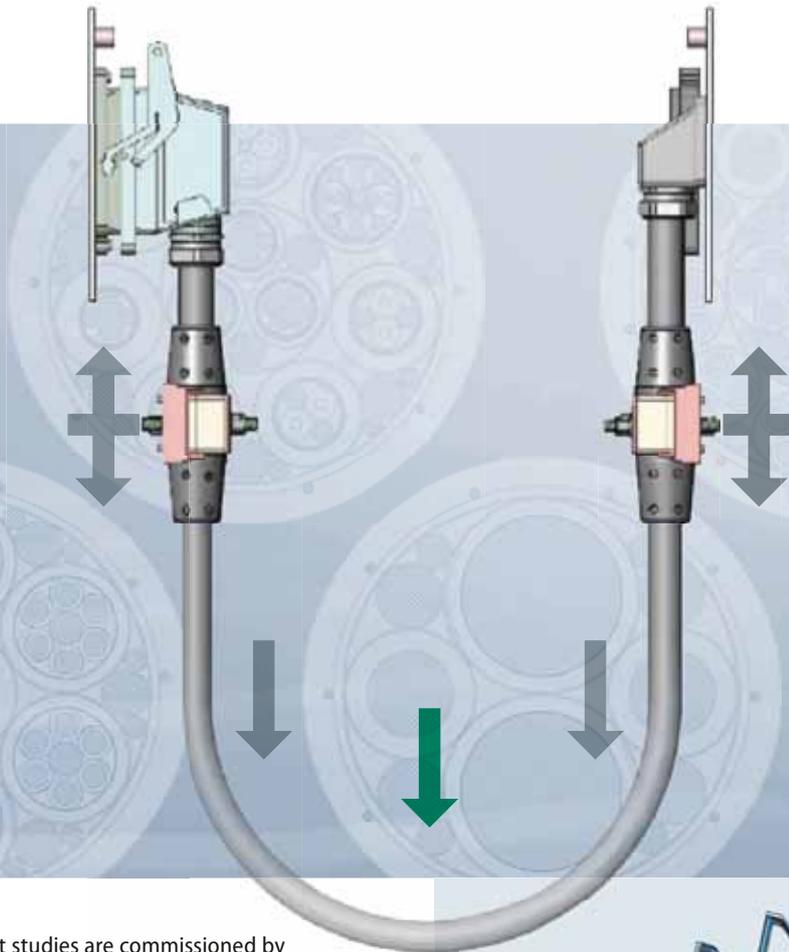
As your development partner, we supply application-specific system solutions. This includes, in particular, rolling stock jumpers and high-voltage roof jumpers, cable harnesses for device wiring and cable assemblies for economical and functionally safe wiring of switch cabinets, panels, blocks and entire carriages.

In the process, we draw on our experience and competence gathered in the following areas:

- Mechanical construction and electrical construction, as well as the installation of overall systems
- Cable construction and engineering
- Material development
- Interface design, including optimisation/adjustment for the plug connectors
- Computer-supported simulation and real product and service life tests
- Life cycle cost optimisation

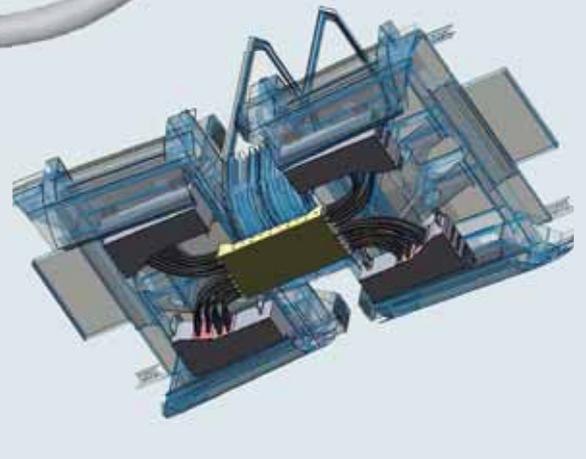
The service life of our system solutions in continuously moving use is more than 8 years.

Feasibility and concept studies



Feasibility and concept studies are commissioned by our OEM customers in order to be able to offer fast and technically feasible interface solutions if an order is placed. These may include very diverse specifications for the solution, because the railway operators have country-specific requirements for the availability of the rolling stock used by our customers.

For instance, an entirely new solution concept was developed for electrical rolling stock jumper systems for high-speed trains. Based on the framework conditions specified by the customer, several solution approaches were developed and discussed, evaluated in regard to their efficiency and incorporated into specification books by the customer as required specifications. The requirements on rolling stock jumper systems extend from the required electrical properties to the resistance to extreme weather conditions to the mechanical resistance of the systems.



Within the scope of a feasibility study, a particularly high capacity for the accommodation of vertical forces, among other things, was required by the customer. For the fulfilment of this design specification, a special strain relief system tailored to the respective specific fastening interface was developed and can be validated as a complete system.

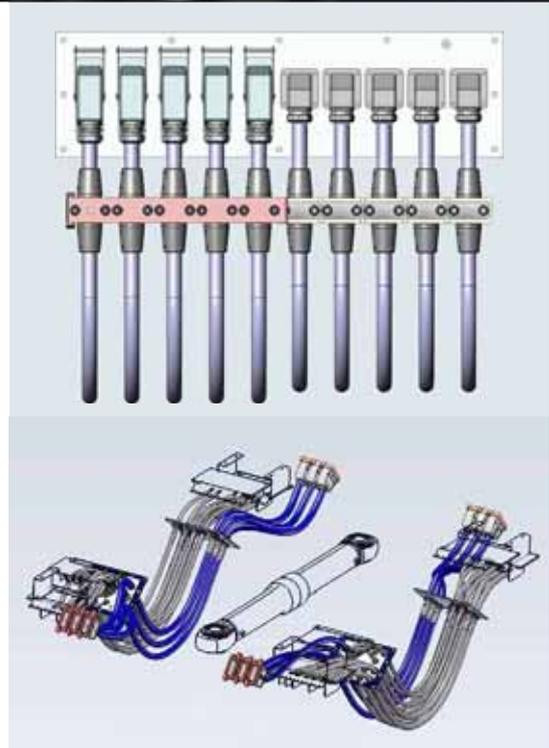
Rolling stock jumper systems

Rolling stock jumper systems from LEONI are designed for areas between vehicles and/or carriage bodies and bogies subjected to high mechanical stress and specially developed for each individual installation situation.

They are normally designed as a breakout cable between the face ends of the carriage bodies, as a roof or under-floor jumper system. In regard to the cable design, consisting of power, control data bus, fibre optic and/or coaxial cables and in regard to the mechanical design of the cable mounting and guide, LEONI can solve even the most complex problems with the company's extensive experience.

In order to satisfy high demands on flexibility, functionality and service life, we use especially high-quality materials and specially developed connecting systems with corresponding plug connectors and connection components.

We also have a wide variety of testing means for the development and inspection of functionality and service life.





BENEFITS for OEMs and operators

- One **development** and **system partner** assures an **improved technical solution** with reduction of interface costs
- **Optimally matched components**
- With the LEONI value added chain, a customer-specific solution and the fastest availability are even **possible on the component level**
- Product qualification and safeguarding by means of **service life testing**
- Simple, safe and quick installation, **reduced process costs**



High voltage roof jumpers



High-voltage roof jumpers for the transmission of energy from carriage to carriage.



LEONI' roof jumper designs include double spirals, which guarantee an optimal bending resistance and elasticity with a demanding cable design and the use of specially developed jacket and insulation materials, for even the highest mechanical, physical and chemical demands. The highly flexible cable system permanently compensates for vibrations as they arise and distance changes of up to ± 1000 mm. High hydrolysis resistance, good rebound properties at temperatures of -30°C to $+80^{\circ}\text{C}$ and high resistance to UV radiation are also provided. The cable satisfies the standard IEC 60332-1.

BENEFITS for OEMs and operators

- Complete compensation of three-dimensional relative movements of the fixation points*
- High service reliability with redundant arrangement (double spiral), electrically or mechanically
- Available in various cross-sections depending on the network layout
- Secured insulation section to the bellows even in the event of a spiral tear with inherent stability
- Attachment to supports or sealing end
- Customer/application-specific connection
- Product qualification and safeguarding by means of service life testing

* LEONI engineering (calculation, construction)

Built-to-print



Based on the 2D representation from the design-to-build process, the cables systems are produced and assembled in-house. The term build-to-print refers to the cable assembly (build) using the printouts (print) affixed to harness boards.

- Cutting to length
- Marking
- Assembly
- Retention test (test for the correct engagement of the crimp contacts within the plug)
- Electrical test for continuity (network testing), insulation breakdown strength, four-pole measurement on customer request
- Inspection (visual inspection for obvious defects)

In addition to the supply of assembled cable systems, our services include system technology. We develop mechanical and electronic assemblies from the prototype to the market-ready product.

Refurbishment



Modernisation, general overhaul, retrofitting for optimal progression of refurbishment projects are carried out through close collaboration between project managers and system engineers with the experts from production and assembly.

Through collaborative work, we analyse the special installation situation, look for possibilities that fit the present conditions and implement the best possible solution.

Worldwide presence

We are represented in all important industrial regions

Testimonials



Close proximity to the customer is a key to our success. Our worldwide presence makes it easy for our partners to utilise all our service quickly and without complication.

- Global production and service network
- Ensuring high product availability
- Process monitoring and process and product optimisation on site
- Customer-specific logistics solutions
- Installation on site
- Spare parts management



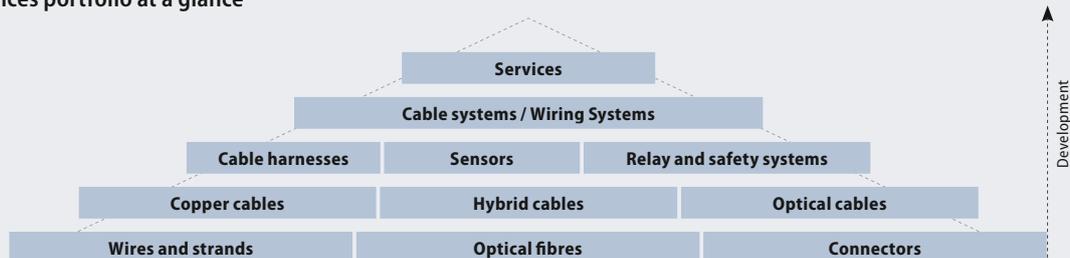
Our customers include numerous renowned companies

- | | |
|---------------------------------------|--|
| ■ Alstom Transportation | ■ Matisa Materiel |
| ■ Bombardier Transportation | ■ MVG (Münchner Verkehrsgesellschaft GmbH) |
| ■ BVG (Berliner Verkehrsbetriebe) | ■ Österreichische Bundesbahnen |
| ■ CAF | ■ RhB Rhätische Bahnen |
| ■ CMKS | ■ Schweizerische Bundesbahnen |
| ■ CNR Changchun Railway Vehicles Ltd. | ■ Siemens Mobility |
| ■ CNR Tangshan Railway Vehicles Ltd. | ■ Skoda |
| ■ CSR Zhuzhou E.L.W. | ■ Stadler Rail |
| ■ Deutsche Bahn (German rail service) | ■ Vossloh Kiepe GmbH |
| ■ Gmeinder Lokomotivfabrik GmbH | ■ Windhoff Bahn- und Anlagentechnik GmbH |
| ■ Graz-Köflacher Eisenbahn | ■ ZOS Trnava |
| ■ HYUNDAI Rotem | |

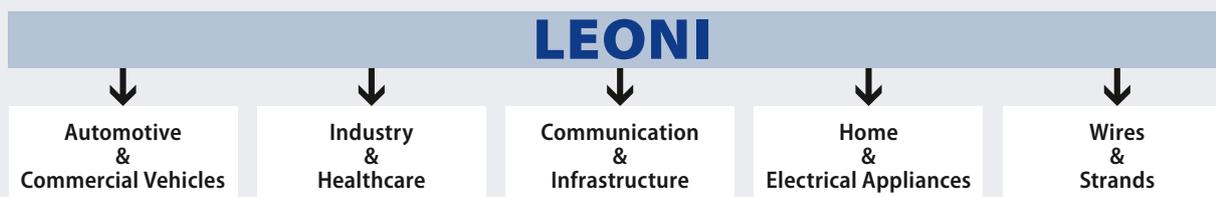
The LEONI Group

Cable competence for different industrial markets.

Products and services portfolio at a glance



LEONI's core markets



LEONI is a leading supplier of cable systems and related services for the automotive industry and various other industrial sectors.

Our group of companies employs more than 66,000 people in 33 countries. Corporate vision, highest quality and innovative power have made us one of the leading cable manufacturers in Europe. LEONI develops and produces technically sophisticated products ranging from wire and optical fibres to cables through to complete cable systems and also offers the related services. Moreover, the product portfolio comprises strands, standardised cables, hybrid cables, glass fibre as well as special cables, cable harnesses, wiring systems components and fully assembled systems for applications in various industrial markets.

Your markets – our strength.

As diverse as our product and service range are the markets and sectors LEONI is supplying. We focus our activities on customers in the fields of Automotive & Commercial Vehicles, Industry & Healthcare, Communication & Infrastructure, Electrical Appliances and Conductors & Copper Solutions.

We are among the leading European suppliers in the Communication & Infrastructure market to which at LEONI as a cable manufacturer also belong activities in the fields of infrastructure & data communications, industrial plant projects, solar- and wind power, energy & telecommunications, irradiation cross-linking and traffic engineering. Our customers benefit worldwide from innovative as well as reliable and long-lasting products of high quality. LEONI – we provide the best connection for your future.

For further information, visit www.leoni.com

Green Technology

Our company aim is to combine innovation with sustainability. It is one of our central company goals.



Our vision is to create sustainable connections in technological harmony with the natural resources. The cycle of nature gives us the best model to emulate. It is our responsibility to learn from nature and make use of it while conserving it and treating it with care. The growing scarcity of the natural resources and the increasing burden on the environment require a rethink on all levels of society. For LEONI, sustainability is an integral part of group policy. We are the first cable manufacturer in the world to develop a holistic concept for “green technology”.

While trends like globalisation, mobility and urbanisation also determine the markets, sustainability and global responsibility are a central credo. To be considered the most innovative cable manufacturer for environmentally friendly technologies – that is our goal. At that, it is of vital interest to us to detect the needs and requirements of tomorrow today and supply the markets of the future with sustainable, future-proof solutions.

Green technology stands for the resource-conserving and low-emission production of sustainable quality cables made with low-pollution elements. We constantly work at optimising the efficiency with which resources are used in the manufacturing process by deploying energy-efficient machines or taking heat recovery measures. More and more locations in our global production network are environmentally certified according to the ISO 14001 standard.

As a worldwide active and leading European supplier of wires, optical fibres, cables and cable systems for communication and infrastructure projects it is our responsibility to constantly optimise the sustainability and durability of our products, system solutions and services and thus lower the environmental load. We have to increase the amount of environmentally compatible raw materials in our cable products as well as the recyclability of processed materials or components and in doing so create end products that are developed for the environmental standard of tomorrow today.

In conjunction with the ecological compatibility, future technologies are measured in terms of efficiency, service life, emission reduction and the conservation of natural resources. Innovative cable products and systems, holistic solutions and maximum performance in project management are the added value which we offer to our customers and business partners. These are also our cornerstones for strong connections into the future.

There are various environmental directives in the European Union (EU). The Directive 2012/19/EU WEEE (Waste Electrical and Electronic Equipment) regulates the disposal of electrical and electronic equipment and components.

The use of certain hazardous substances in electrical and electronic equipment is regulated by the Directive 2011/65/EU RoHS 2 (Restriction of Hazardous Substances). Chemicals and substances in generally are covered by the Chemicals Act, 1907/2006/EC REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals).

This means avoiding the following substances, among others:

- Polybrominated diphenyl ether (PBDE)
- Decabromodiphenyl ether (DecaBDE)
- Perfluorooctane sulfonate (PFOS)
- Pentabromodiphenyl ether (PentaBDE)
- Octabromodiphenyl ether (OctaBDE)
- Lead (Pb)
- Mercury (Hg)
- Cadmium (Cd)
- Hexavalent chromium (Cr VI)
- Polybrominated biphenyls (PBB)



Cables and conductors and their associated connectors are only affected by the above guidelines where they are an internal part of the listed equipment and components.

Cables and conductors have been regulated separately in 2011/65/EU RoHS 2 since 2013 (category 11 or defined as an internal component of the respective product). This does not pertain to optical fibre cable, energy cable (> 250 V) and cable with fixed installation, e.g. in buildings. The only permissible identification according to RoHS 2 is the CE mark, which is printed on the product package.

EU Directive 2012/19/EU on waste electrical and electronic equipment

EU Directive 2011/65/EU for restriction of the use of certain hazardous substances in electrical and electronic equipment.

EU Regulation 1907/2006/EC (REACH) the chemical regulation of the European Union.



REACH

What does REACH mean?

REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals.

With REACH, the previous chemical law was basically harmonised and simplified with applicability in all EU Member States.

There are so-called candidate lists under REACH, which contain Substances of Very High Concern (SVHC) that are subject to information obligations and should be replaced with other materials in the long-term. The list of candidate substances is updated twice per year by the European Chemicals Agency (ECHA) in Helsinki.

Further information:

Business Unit Transportation

www.leoni-transportation.com

rollingstock@leoni.com

LEONI Studer AG

Herrenmattstrasse 20

4658 Däniken

Switzerland

Telephone +41 (0)62 288 82 82

Fax +41 (0)62 288 83 83

LEONI elocab GmbH

Industriestrasse 27

91187 Röttenbach

Germany

Telephone +49 (0)9172 6844-0

Fax +49 (0)9172 6844-29