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Innovative learning

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The new UIC-certified KEf control valve

KNORR-BREMSE

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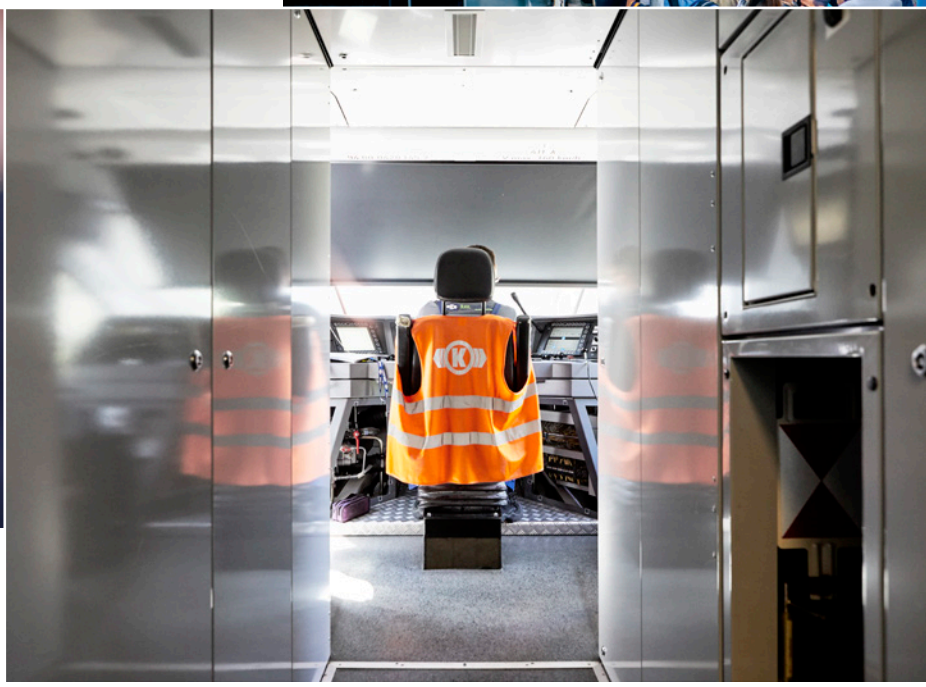

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Harald Schneider,
Member of the Management Board
of Knorr-Bremse Systeme für
Schienenfahrzeuge GmbH

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AND BUSINESS PARTNERS

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Dear reader,

The 21st century is the century of cities. Today, more than half of the world's people already live in urban agglomerations, and it will be these areas that experience the largest growth in population over the coming years, especially in emerging and developing countries. Accordingly, the outcome of the sustainability challenges facing our planet will be determined by what happens in our cities, not least in the freight and passenger transportation sector.

This issue of informer highlights the ways in which our industry can help to shape the course of urbanization, with a special focus on Delhi in India and Riyadh in Saudi Arabia. Although these two cities have very different stories, they face similar challenges as a result of their extremely rapid growth.

Next, we turn our eyes to the future in an interview with Dr. Jürgen Wilder. A good year after taking up his position as Member of the Executive Board of Knorr-Bremse AG with responsibility for the Rail Vehicle Systems division, Dr. Wilder outlines the solutions that Knorr-Bremse is developing to meet these challenges.

The Reproducible Braking Distance research project is one example. Its aim is to ensure that rail vehicles are reliably brought to a halt at the same point, regardless of weather conditions. As well as helping to increase the capacity of the existing network infrastructure, high-precision braking is also a key enabler of the next steps on the way towards automated driving. These brakes are therefore anything but a limiting factor – they open up new possibilities!

Also featured in this issue is our innovative deceleration control system, which forms part of the Brake Distance Management project. This significantly reduces braking distance variation – and will shortly be authorized by the Polish Office of Rail Transportation for use on a three-car regional multiple unit.

We also turn the spotlight on New York, where Knorr-Bremse's legendary VV120 compressor is receiving a new lease of life as part of a universal air supply unit designed for the widest possible range of applications. I would also encourage you to read the item about the successful launch into commercial operation of our new generation of KEf control valves. Their consistently modular design has reduced the number of different versions from around 500 to just 50 – an enormous advantage, particularly in terms of maintenance costs.

As an exciting year draws to a close, I would like to take this opportunity to wish you and your families a relaxing Christmas and a successful start to the new year.

Yours sincerely

Harald Schneider

news

New equity investments

Knorr-Bremse is taking the next step towards system solutions for automated rail transportation and strengthening its digitalization strategy with solutions for improving asset availability.

Rail path recognition for Knorr-Bremse's collision avoidance system for LRVs is just one application of a technology developed by Israeli start-up RailVision, in which Knorr-Bremse acquired a 21.3% share in March. The technology could also be used to detect track and infrastructure maintenance requirements, enabling targeted, cost-effective maintenance work. RailVision is a world-leading provider of such cognitive vision sensors and safety systems for the rail industry.

"RailVision has a dynamic and professional team with extensive expertise in artificial intelligence and deep learning," explains Dr. Jürgen Wilder, Member of the Executive Board of Knorr-Bremse AG with responsibility for the Rail Vehicle Systems division. "Its video- and infrared-based obstacle detection systems will position us as a key player in this market and help us to move a step closer to the goal of automated transportation." Knorr-Bremse made this investment with a view to offering its rail customers highly integrated systems for automated transportation. For its part, RailVision was looking for an established corporate partner in the rail industry.

RailVision recently completed a long-term pilot project that demonstrated the system's ability to detect and classify obstacles at distances of several hundred meters in real time – a capability that offers important benefits for cargo operators in shunting yards. The company has also made substantial progress in the development of its mainline solution for detecting objects at distances of up to 2,000 meters. Its add-on big data module concept enables customized real-time and offline analysis of rail infrastructure and its surrounding ecosystems.

Digital fleet management solutions with Railnova

In May, Knorr-Bremse strengthened its digitalization strategy with solutions for improving asset availability through the acquisition of a 32% minority stake in Railnova SA. The Belgian company is an innovation and technology leader in telematics solutions and maintenance workflow software for the rail industry. Its technology can be used on any rail vehicle and provides digital fleet management solutions for operators, lessors, maintainers and manufacturers. With more than 1,500 installed units, the company's business model is already market-proven.

From Poland to Greece

More than 800 teams took part in the 12th Złombol charity rally that started in Katowice, Poland, and finished over 2,000 kilometers away on the Chalkidiki peninsula in Greece. What makes this rally unique is that participants are only allowed to use cars built during the communist era. Rafał Olszewski, Tomasz Bucior, Anna Mitoń and Paweł Puskraczy, all from Knorr-Bremse Poland, got hold of a Polonez station wagon and entered the rally as the "Kombi na tory" team.

Together, they planned their route, stopovers and accommodation and overcame the technical challenges thrown up by their ageing vehicle, such as a temperamental ignition or a broken exhaust pipe. During the 13 days it took them to complete the rally, the team traveled over 4,500 kilometers through Slovakia, Hungary, Serbia and North Macedonia before finally arriving at Chalkidiki. Their return route took them through various other countries, including Albania, Montenegro and Croatia. The 800 teams raised approximately €432,000 for charity, for instance by selling advertising space on their vehicles.

Charity rally – from Poland to Greece

Direct feedback

Where is customer satisfaction high and where is there room for improvement? How does Knorr-Bremse compare with its competitors? Our online customer satisfaction survey takes just a few minutes of our customers' time, but provides Knorr-Bremse with extensive feedback on how it can fine-tune its operations to meet market requirements even more successfully. We have been running a regular, centrally organized customer satisfaction survey for several years, with separate versions for the European OEM brake business and the global RailServices business. The aim is to ensure comparability of the results across the years.

We have now analyzed the results of the latest survey – and while they confirm that we are on the right track, they also provide us with motivation to do even better. Average customer satisfaction remains high, and in some cases is even slightly higher than in the previous survey. However, the survey also flagged up a few areas where there is room for improvement. For instance, customers would like shorter lead times and greater flexibility in terms of how projects are implemented.

The first of its kind

In September, the German Federal Railway Authority issued its final authorization for the commissioning of Desiro Classic VT642 vehicles with a modernized braking system. Knorr-Bremse RailServices had replaced the MRP control unit designed in the mid-1990s with the new ESRA Evolution brake control system. The commissioning authorization means that the modernized vehicles can now operate on the German rail network without restrictions.

There is no longer anything standing in the way of other vehicles receiving the same upgrade. Negotiations concerning further upgrade deals are in some cases already well advanced, both in Germany and in other European countries with sizeable Desiro Classic fleets. The first upgrade kits for prototypes are already on order.

Deutsche Bahn (DB) has already ordered 155 braking system upgrade kits, and in other European countries with sizeable Desiro Classic fleets, negotiations are well advanced.

news

Think global, act local

Two new Knorr-Bremse Global Care organizations – in the USA and Hong Kong – are strengthening local responsibility and promoting the involvement of Knorr-Bremse employees around the world.

In Brazil, Knorr-Bremse Global Care has given 36 young people the chance to learn construction skills with the help of local NGO Instituto Anchieta Grajaú. In Tanzania, it has worked with World Vision to provide access to clean drinking water and improved sanitation in elementary schools. Despite their differences, these two projects are representative of two key Global Care support areas: education and WASH (water, sanitation and hygiene).

Established a few days after the catastrophic tsunami that hit South-East Asia on December 26, 2004, Knorr-Bremse Global Care has continually expanded and professionalized its work. In 2018 alone, it reached 20,871 people and invested nearly €1.7 million in 54 projects. The organization is predominantly funded by the Knorr-Bremse Group and by donations from employees. It relies heavily on the commitment of its members and on the Group's workforce, some of whom take on roles as project supervisors, for instance.

More effective in the long term

"We see ourselves on the one hand as a professional partner for financing development projects," says Julia Thiele-Schürhoff, Chair of Knorr-Bremse Global Care. "But we also see ourselves as a learning organization, keen to tackle social challenges with a clear focus." The question has always been how the organization could expand its local activities, while integrating more employees into its work. "Those who know a country's culture, speak the language and are familiar with local needs and characteristics, work more effectively in the long term."

It is precisely this vision that is reflected in our improved organizational structure: In the future, Knorr-Bremse Global Care in Germany will look after activities in European countries, in Brazil – where projects are supervised by Knorr-Bremse Global Care Brazil – and in South Africa. It will also coordinate aid projects in countries without a Knorr-Bremse site. Knorr-Bremse Global Care North America will carry out funding and project work in the USA, Mexico and Canada, while Knorr-Bremse Global Care Asia Pacific will oversee projects in India, China, Japan, Australia and the Pacific Rim.

Independence within a common framework

Despite the autonomy of the new units, they still fall under the shared umbrella of Knorr-Bremse Global Care. "The regions have to comply with certain basic conditions, such as the requirement to support projects primarily in the area of education," explains Thiele-Schürhoff. "But they are otherwise entirely independent."

▲ The project in Elyria provides an after-school program for young people

Impressions of this year's TRAKO fair in Gdańsk

Knorr-Bremse at TRAKO

The TRAKO International Railway Fair is Poland's largest and most prestigious rail industry event. This year was the first time that Knorr-Bremse was represented on the TRAKO program committee. Under the motto "Systems.People.xConnected", the Company also presented an overview of its solutions for the market drivers of system connection, life-cycle efficiency, availability & transport capacity, and ecodesign.

These included the iCOM digital platform and several of its applications for efficient and cost-effective rail transportation. Knorr-Bremse's EP2002 3.0 brake control system showed how modular products can deliver sustained optimization of maintenance requirements. Sanding systems, testing equipment and a range of products and systems from Microelettrica Scientifica and Zelisko were also on display. Furthermore, several other Knorr-Bremse solutions, applications and services were presented using digital animations and graphics, providing visitors to the Company's booth with a clear illustration of the concrete customer benefits.

1,674 doors for 279 vehicles

Most of the 500,000 passengers who use Lisbon Metro every day travel on ML95, ML97 and ML99 vehicles. The Knorr-Bremse Group has been awarded the contract to carry out an extensive modernization of the door systems of all three series.

Knorr-Bremse España, IFE Ibérica and Knorr-Bremse GmbH's IFE division will modernize 1,674 doors on 279 vehicles that entered service between 1997 and 2002. The main components being renewed include motors, clutches, spindles, limit switches and rollers. The entrance systems will also get new non-slip floor surfacing, while the ML99 series will be fitted with the new generation of MDC Door Control Units.

The modernization work is scheduled to take just 36 months, including installation and repainting of the door leaves, if required. In order to minimize the time that the vehicles are out of service, Knorr-Bremse will be carrying out the work on site at Lisbon Metro's workshops.

IFE door systems on the Lisbon metro

news

A robust unit

25 years and still going strong – Knorr-Bremse's VV120 compressor has been chosen to replace the aging compressors on the New York City Subway. NYCT demanded maximum reliability – and that is exactly what they got with the Knorr-Bremse VV120.

The New York City Subway ▲
Installation of the VV120 compressor ▶

It's fair to say that there are less hostile environments for compressors to operate in. Environments where the tunnel air is not saturated with a black soot made up of sand, carbon, abraded rubber particles and steel dust. Environments without the extreme temperature and humidity changes experienced by vehicles in winter, when one minute they are in a warm tunnel and the next they are out on an elevated rail line in the middle of a snowstorm. And environments without the shaking and rattling rails that the New York subway is so famous for. Not to mention the fact that the subway operates 24/7, forming the backbone of one of the world's largest cities. Quite simply, if the New York subway isn't running, the city comes to a standstill.

VV120 compressor is the ultimate workhorse

In view of these tough operating conditions, when the New York City Transit Authority (NYCT) wanted to make significant improvements in the performance of their existing fleets, reliability was at the top of their list of requirements. They wanted an air supply unit to replace the aging compressors on their older vehicles. Knorr-Bremse carried out studies and concluded that not only could we make a 50% improvement, but be it would be possible to design a unit that would be more widely suitable for a variety of different car types. Instead of having the existing compressors continually repaired and overhauled on intervals much shorter than the VV120, NYCT decided to conduct a trial with the Knorr-Bremse units.

The VV120 brings additional benefits as it allows for the five-car train to replace the three current air supply units with only two from Knorr-Bremse. This further enhances reliability and reduces weight and maintenance costs even further.

The VV120 compressor has long since proved successful in the R44 fleet and forms the core of the units that Knorr-Bremse supplied in the initial demonstration. Robust and virtually indestructible, more than 22,000 units of this legendary compressor have been sold over the past 20 years. Knorr-Bremse's annual VV120 production has increased more than tenfold since the end of the 1990s. Originally deployed in Bangkok and Guangzhou, it soon became the compressor of choice throughout Asia and now supplies compressed air to thousands of metro trains every day.

"This compressor is the ultimate workhorse and one of the most valued systems in the Asian rail market," says Richard Stelmach, Deputy Director of the North American Knorr Brake Company. Its overhaul cycle can be as long as ten years, and most operators can carry out the straightforward overhaul procedures in their own workshops.

New units instead of overhauling existing compressors

As well as the VV120 compressor, the unit includes the power supply and air treatment components plus safety valves and tubing. "The trick was to combine the different components to create a universal air supply unit for the widest possible range of applications," explains Stelmach. A special adapter is included for older vehicles. "This air supply package is ideally suited to these applications."

The VV120 has strong credentials in terms of low noise and vibration, higher reliability, and robustness – all its bearings, pistons and cylinders are lubricated with splash oil. Splash lubrication dispenses with the need for additional equipment such as oil filters and oil pumps. Moreover, the fact that the crankcase exhaust is filtered before being fed back into the intake duct prevents oil from escaping into the environment.

Orders and innovations

Knorr-Bremse company Kiepe Electric delivers efficient, customized solutions for the mass transit market. Here, we provide an overview of some of the latest developments.

Busworld Europe 2019: new solutions for sustainable urban transportation

Efficient solutions for sustainable transportation were undoubtedly the main focus at Busworld Europe 2019 in Brussels (October 18-23, 2019). Knorr-Bremse CVS and Kiepe Electric used the opportunity to showcase their strategies, products and services. The new Kiepe Traction Inverter (KTI) was premiered, and impressive new e-drive products from Knorr-Bremse CVS such as the iAPU Intelligent Air Processing Unit were also on display.

KTI: the new traction inverter for electric buses and electric commercial vehicles

There have also been new developments on the systems front. Currently still under development, the new Kiepe Traction Inverter (KTI) is a power converter that combines the power electronics for the traction system and for battery charging in a single system. Designed for use in electric buses and electric commercial vehicles, and featuring the highest power density currently available in the market, the KTI is scheduled for pilot testing in the middle of next year.

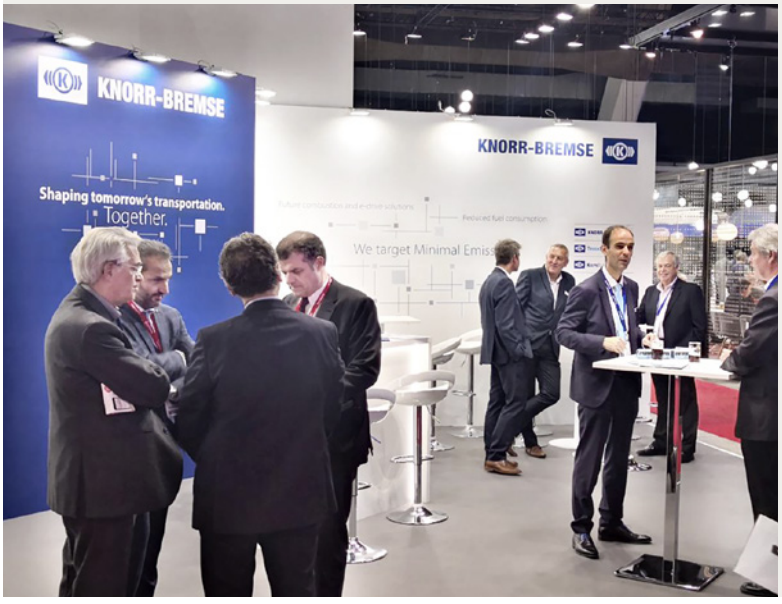
The clean solution: 30 Solaris IMC® buses for Milan

As part of the electrification of its bus fleet, Milan's transit authority ATM has ordered 30 buses from bus manufacturers Solaris. Kiepe Electric is supplying all the electrical equipment, comprising traction power converters, motors, high-performance 45 kWh lithium titanate oxide traction batteries, and auxiliary systems. The groundbreaking In Motion Charging (IMC) concept is at the heart of this clean solution for the urban infrastructure. During operation the vehicle draws up to 500 kW of power from the overhead lines (200 kW for battery charging, plus power for traction and auxiliary units). The vehicle then operates as a battery-powered bus on sections of the route where there are no overhead lines. The buses can achieve a range of up to 18 kilometers (11 miles) without needing to spend long periods of time recharging at the terminuses.

Dual homologation: last LRVs delivered to Karlsruhe

During the summer, Kiepe Electric and vehicle manufacturers Stadler Valencia delivered the last of 75 Citylink NET 2012 low-floor LRVs to the city of Karlsruhe. "This project draws on our wide-ranging expertise – the vehicles have achieved dual tramway and light rail homologation, their sub-systems have been integrated with the electrical control system and they also feature an innovative HVAC system," says Managing Director of Kiepe Electric, Dr. Heiko Asum. The dual homologation means that the operator can use the 37.2-meter-long vehicles on both the Karlsruhe tramway network (BOStrab regulation) and the S1/S11 light rail lines that also serve the area around the city (EBO regulation).

▼ Impressions of this year's Busworld fair in Brussels



spotlight

Quelle: UN DESA, 2018

A NEW HEARTBEAT

Our growing megacities pulsate with traffic – yet it is now threatening to choke them. There is an urgent need for intelligent solutions that are fast, safe, clean and reliable. Rail transportation can often provide the answer – and Knorr-Bremse is helping to make this possible.

The volume of road traffic in Delhi has soared in recent years, and the city's potholed streets are now packed fender to fender with vehicles, accompanied by the deafening sound of horns. According to the World Health Organization (WHO), India's capital has the worst air quality of any major city in the world.

There are currently 33 cities across the globe that are home to more than ten million people, and this figure is projected to rise to 43 within the next ten years. Delhi is by no means unique in having a population that is growing by almost 2.5% a year. However, the Indian megacity vividly illustrates the urgent need for a transportation infrastructure that meets the needs of people, freight and the environment.

The challenges begin at the planning stage. Local transportation has to serve the ancient heart of Delhi with its winding alleyways, New Delhi with its generously mapped out colonial boulevards, and the extensive suburbs with their office blocks and shopping malls.

The city opened its first metro line in 2002. Today there are eight lines with 327 kilometers of track and 297 trains, and construction work is scheduled to continue until 2024. Opened at the beginning of 2019, the new Aqua Line is helping to ease the daily gridlock on the roads of Noida, a city of 642,000 inhabitants on the affluent outskirts of Delhi. Built entirely on elevated track, the 30-kilometer line serves a total of 21 stations.

The trains were built by Chinese manufacturers CRRC and feature Knorr-Bremse braking systems that optimize the vehicles' wheel-rail adhesion. A sophisticated system ensures optimal load distribution across the vehicle's axles. This enables shorter braking distances, which in turn increases transportation capacity by allowing trains to run more frequently. Safety also benefits from the enhanced braking distance control.

Riyadh: a mass transit revolution

The story of Saudi Arabian capital Riyadh's development could hardly be more different from that of Delhi. Riyadh only started growing rapidly in the 1950s, when the Indian capital was already home to millions. In recent decades, Riyadh's urban development has taken its lead from the US model, with a settlement structure resembling a chess board, interspersed with broad boulevards. But with the city's population expected to exceed ten million by 2035, even this sound infrastructure is gradually reaching its limits. To some extent, Riyadh is actually facing many of the same problems as Delhi.

Efforts to address these issues are centered on the King Abdulaziz Public Transport Project, a high-capacity metro system that is currently under construction. Six lines adding up to almost 180 kilometers are due to be built in the project's first phase, complemented by a coordinated network of bus services.

The Saudi media are describing it as nothing less than a mass transit revolution in a city where people are accustomed to traveling in the comfort of their own cars. Expectations in terms of architecture, vehicles, punctuality and comfort are all correspondingly high, as are the requirements for functionalities such as the HVAC system.

As well as the braking systems, the Knorr-Bremse Group is also supplying several sub-systems such as the HVAC and entrance systems for most of the Riyadh metro vehicles. The HVAC systems come from Knorr-Bremse's Australian subsidiary Sigma Air Conditioning, while the entrance systems are provided by IFE in Kematen an der Ybbs, Lower Austria.

As well as delivering greater safety thanks to their obstacle detection capability, the entrance systems also support intelligent passenger flow management that enables more efficient operation of the entire metro system. For example, rapid boarding and disembarking is facilitated by the visual and acoustic signals given as the train doors open and close.

Automated driving – the next steps

More than a year has now passed since Dr. Jürgen Wilder, 49, took up his position as Member of the Executive Board of Knorr-Bremse AG with responsibility for the Rail Vehicle Systems division. In this interview with informer, he discusses some of the future developments he expects to see in the industry.

Interview with Dr. Jürgen Wilder

Dr. Wilder, will all metros be driverless in a couple of years' time?
It's certainly a possibility, and to some extent perhaps even a necessity. Automated driving makes it possible to reduce the distances between individual vehicles. This allows you to run more metro trains on the same network. In other words, it means you can increase transportation capacity without having to spend a lot of time and money on expanding the rail network. But that doesn't necessarily mean there will no longer be a driver up front in the cab.

What do you mean?
I'm referring to initiatives such as our Reproducible Braking Distance research project. Our future braking systems will help drivers to achieve the same high-precision braking in all weathers. This functionality is set to become extremely important, especially in automated driving, where a given braking operation must always bring the vehicle reliably to a halt at exactly the same point.
Although this type of driver assistance is not the same as fully automated driving, the technology developed for it will certainly be a component of fully automated systems. In Australia, the Rio Tinto mining corporation is already using our LEADER driver assistance system to run entirely driverless trains. And the basic principle is also being employed at Deutsche Bahn, where they are using iCOM Assist as a purely advisory system to help reduce energy consumption.

This spring, Knorr-Bremse acquired a stake in an Israeli start-up called RailVision, which specializes in obstacle detection for rail vehicles. Is this a sign of where things are heading?
Absolutely! RailVision has developed a technology that uses a combination of image recognition and infrared to see up to two kilometers ahead. Under most circumstances, that's better than the human eye. But for safe – and perhaps one day fully autonomous – operation, we must also be able to reliably detect obstacles at this range. This includes things such as people, vehicles, signals and track switch positions. We believe that by combining brakes with other elements we can take the next step towards developing system solutions for automated rail transportation.

Moreover, the use of modern image recognition enables an important additional application – as well as obstacle detection and classification, the technology can also be used to predict track

maintenance requirements. This makes it possible to carry out any necessary maintenance work in a targeted and more cost-effective manner.

You seem to be implying that there will be no such thing as discrete functions in the future.
There will always be something that drives an operator's or vehicle manufacturer's decision to choose a particular new system or functionality. But we can deliver even greater benefits by connecting the vehicle sub-systems and sensors. This is what we mean by "connected systems".

Can you give an example?
Our portfolio includes a Selectron train control management system that we use to enable communication between our sub-systems and their control units. To give a simple example, when the door system informs the HVAC system that the doors have opened, the HVAC briefly reduces its output so that it isn't blowing cold or warm air straight out onto the platform. This is the sort of thing we mean when we talk about eco-friendliness.

The use of vehicle data has huge potential, especially in the service business. What sorts of opportunities are emerging?
Our data collection and analysis systems already provide extremely reliable descriptions of systems' and components' actual condition. This means we can tell with a very high degree of confidence when a part really needs to be replaced. I should make it clear, though, that safety will always be our number-one priority. Nevertheless, extending service intervals through optimized utilization of components' remaining service life will allow us to significantly streamline service cost structures.

Presumably vehicle reliability and availability are also improved?
Absolutely – in a best-case scenario, product-related failures can even be completely eliminated because components that could soon be at risk of failing are replaced before they have a chance to do so. This approach is particularly attractive to operators who face high penalties for train cancelations. By lowering the risk of failures, improved reliability also allows stocks of replacement parts to be reduced. As you can see, everything is connected.

Isn't one potential sticking point the question of who owns all the data?
This is something that the sub-system supplier, operator and vehicle manufacturer need to work out among themselves. Personally, I believe the market is beginning to realize that the added value of this data is very limited in closed systems, but increases rapidly as soon as we start combining different diagnostics.

Apart from data-driven business, what are the other future trends in the industry?
On average, we invest 5.5% of our revenue in research and development, with the main focus on solutions for reducing life cycle costs, protecting the climate and enabling efficient, modern mobility for people in urban areas. Actual product and system innovations are of course paramount. For instance, the megacities of Moscow and Beijing recently decided to order an innovative door sealing system made by Knorr-Bremse company IFE. As well as enhancing the passenger experience with a huge reduction of up to 32 dB(A) in noise levels, the system also supports more energy-efficient temperature regulation by almost completely preventing air from being forced into the vehicle by the headwind.

We also believe that there is great potential in new systems such as automatic couplings that can minimize manual shunting steps. We intend to enter this business and have earmarked research and development funds to this end. We are also working to adapt industrial 3D printing technology for use in the brakes business. This could open up exciting opportunities, for instance for low-volume production with short lead times.

What about the prospects for frictionless brakes?
Although frictionless braking systems certainly won't replace friction brakes overnight, they could be a useful addition for certain braking scenarios. But, as is so often the case in our industry, it's not as straightforward as it seems – there is far more to it than simply reversing the drive of an electric motor. We are currently monitoring this trend very closely and will certainly pursue it if we deem it to have enough potential.

customers + partners

Crossing the continent

Knorr-Bremse RailServices' new roadshow truck is currently touring Europe. A combination of highly informative exhibits and well-trained sales staff explain the very real benefits of the Company's latest service offer.

▲ The iCOM display puts all the information at your fingertips

▲ On the road: the RailServices Truck

Gleaming white, with a glass canopy at the front and a bar table at the entrance, the huge truck is an impressive sight. Go up the four metal steps and you will find yourself in a surprisingly large and well-lit space – the RailServices roadshow truck is really like a modern trade fair booth on wheels. Inside is the full range of Knorr-Bremse's expertise: with exhibits and digital displays, expert sales personnel on hand to answer the most detailed questions – and even a virtual reality tour of the Service Center in Berlin!

"Our aim is to talk directly to our customers and explain our portfolio to them," says RailServices Vice President Mario Beinert. "The smaller rail companies, in particular, think of us just as brake manufacturers and are not really aware of the full range of products and services that we offer." Beinert explains that the Company may be known for its modernization and industrial remanufacturing of braking systems, "but we also need to make people more aware of our customized services and digital offers."

Two-year European tour

The roadshow truck is the right vehicle for this task – in both senses of the word. "We can do much more than just supply operators with spare parts," explains Beinert. "Our carefully designed services can make their lives much easier by freeing them up to focus more on their operational activities."

According to Beinert, the central focus is on increasing vehicle availability and reducing life cycle costs – for example with the help of remanufactured brake components or the iCOM digital platform. One of the applications on this platform is iCOM Monitor, which analyzes data from a wide range of vehicle subsystems as a basis for forward-looking, condition-based main-

Excellent rail services

Customized service packages
Every customer receives a spare parts kit tailored to his precise needs in terms of content and range.

Modernization with upgrades
If a vehicle is already undergoing modification, an upgrade such as the addition of anti-trap protection is an option.

Tools for technicians
Mobile testing systems simplify maintenance of Knorr-Bremse products. A measuring toolkit is an invaluable aid when an entire train is having its brakes checked.

Digitalization
The flexible iCOM platform combines digital services such as predictive maintenance or driver assistance systems that help save energy.

Skills and vocational training
All around the globe, RailServices trains service engineers and conducts rail operators' workshops using the latest methods.

The reconditioned locomotive wheel brake caliper is virtually as good as new

tenance. "The ultimate aim with iCOM is a depot management system that involves diagnostic data being transferred directly as an open task to the customer's SAP," says Beinert. But what if all the operator wants is some spare parts? These can be offered in combination with a carefully designed logistics system that supplies individual customers with customized kits.

Two years of crisscrossing Europe awaits the RailServices roadshow truck. One positive side-effect, according to Beinert, is the fact that his sales colleagues have to actively engage with the entire product portfolio. "This makes them more effective as customer advisers." And in addition to this, the relaxed roadshow atmosphere enables them to pick up direct feedback about how Knorr-Bremse systems perform under real operating conditions.

Added value from the Knorr-Bremse Group

The Knorr-Bremse Group portfolio contains much more than just services: **Kiepe Electric** is a specialist in electrical systems for local public transport rail and road vehicles. **Selectron** offers system solutions in the form of control, network and communications technology for rail vehicle automation. **Merak** specializes in designing and manufacturing HVAC systems for rail vehicles. **Microelettrica Scientifica** develops and produces contactors, disconnectors, resistors and electronics not just for the rail vehicle industry but also for industrial applications.

Doing things differently

Product-based aftermarket services are yesterday's news. The future lies in proactive service models. RailServices shows how this approach can increase availability and extend life cycles.

RailServices personnel at work

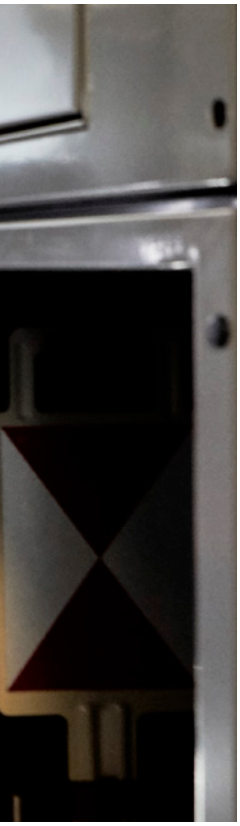
Anyone investing large sums of money in a new locomotive fleet will naturally want it to keep generating revenue for as long as possible. However, during a service life that often stretches over many decades, the vehicles will need several major overhauls. As well as requiring the locomotives to be taken out of service, these overhauls entail high costs for the operator.

"But what if by extending maintenance cycles we could, over the course of a vehicle's service life, dispense with one of these overhauls and all the associated expense?", asks Meike van t Hoen. The Head of Product Management at Knorr-Bremse RailServices answers her own question without missing a beat. "It would significantly reduce overall maintenance costs."

Knorr-Bremse's Operational Optimization Service model is based on a long-term contract that RailServices signs with the operator, covering all the Knorr-Bremse systems in their vehicles. "We use operating data acquired from our digital platform iCOM to enable individually optimized operation and maintenance," explains qualified engineer van t Hoen. Exploratory dismantling of the relevant systems can also be included as part of the deal. The aim is to optimize utilization of the products' and systems' remaining service life and eliminate unnecessary maintenance work. Moreover, operators can cut their transaction costs, choosing between a time-based or performance-based billing model.

Availability Services – ensuring critical operating component availability

With older vehicles that are due to remain in service for several more years, the question of spare parts availability becomes increasingly important to operators. But thanks to RailServices, they no longer need to worry about the associated risks. Rather than simply providing individual aftermarket services, Availability Services offer comprehensive availability guarantees for spare parts and critical operating components.



A clear overview with the iCOM digital platform

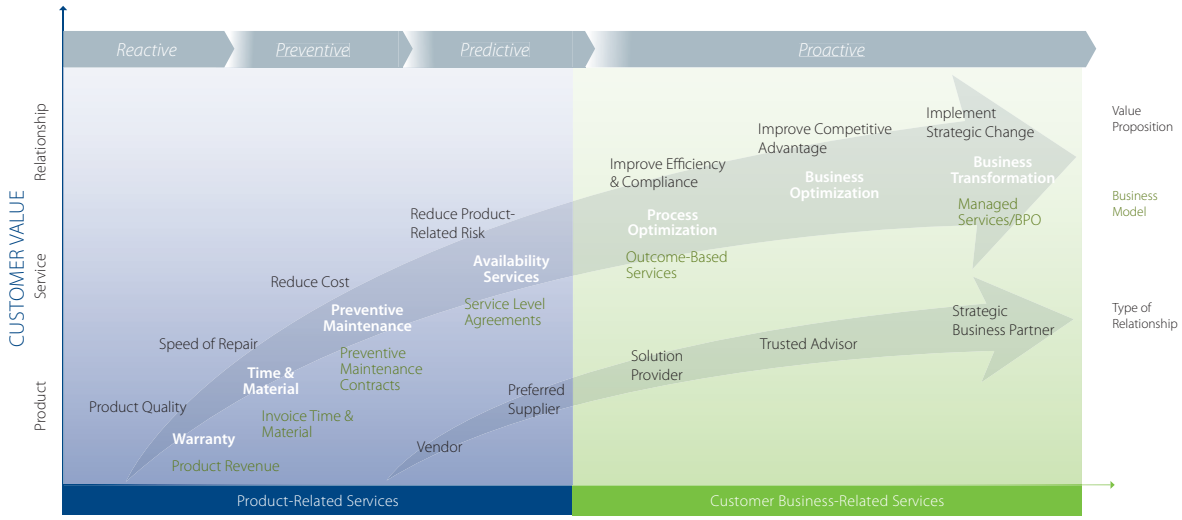
Depending on the operator's particular wishes or requirements, the guarantees can cover anything from individual components to obsolescence solutions or the availability of entire subsystems such as HVAC and entrance systems. They can stipulate customer stock arrangements or specify that Knorr-Bremse should hold a certain quantity of safety stock. This reduces the number of product-related faults, facilitates planning during the remainder of the vehicle's service life and increases fleet uptime.

Minimizing costs through integrated planning coordination

As a one-stop provider, RailServices can also organize maintenance and repair operations. Despite its service not being tied to any particular manufacturer or operator, it always offers in-depth operational, system and product know-how. Having a single service provider simplifies the procurement and supplier management processes, as well as ensuring integrated planning coordination that makes it possible to carry out several service operations in parallel while the vehicle is in the depot. Our one-stop service also means that customers don't have to worry about investigating the causes of problems or waste valuable time fixing them.

Energy Saving Services harness Knorr-Bremse's expertise to significantly reduce vehicles' energy consumption. Combined with digital services, they offer an integrated approach to energy-saving for braking, HVAC, door and traction systems.

KNORR-BREMSE'S POSITION IN THE TYPICAL SERVICE BUSINESS EVOLUTION



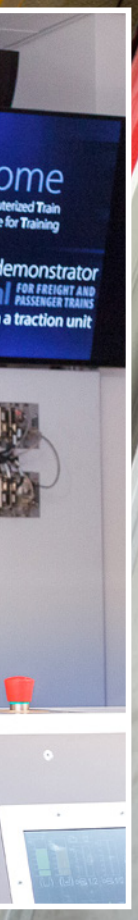
Learning from the market leader

Knorr-Bremse's customer training portfolio draws on the technical know-how accumulated from over 114 years' experience in the rail vehicle industry. Our new training catalog is due out soon.

While there is no doubt that high-quality systems are indispensable for a train's safe operation, they are not the only factor. Operators need to keep up with the latest technological developments in the market and ensure that their personnel have an in-depth, up-to-date knowledge of vehicle subsystems. This is where Knorr-Bremse's extensive, high-quality training portfolio comes in.

With a modular structure that allows them to be easily tailored to customers' individual requirements, our courses encompass both theoretical learning and practical training and are available either at Knorr-Bremse training centers or on-site at the operator's own facilities. Our training content is constantly updated to reflect the latest industry developments. The new training catalog will shortly be available on the Customer Training page of the RailServices website.

Presentation of the CT2 air brake system demonstrator by Dr. Peter Berger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CT² air brake system demonstrator

Knorr-Bremse celebrated the latest addition to its Training Academy in Berlin in mid-November, with the inauguration of its CT² rail vehicle air brake system demonstrator. CT² stands for **C**omputerized **T**rain **C**onsole for **T**raining. It adds an important practice-oriented component to Knorr-Bremse's training and professional development portfolio, enabling hands-on demonstration and visualization of braking systems' complex functionality.

As well as using the demonstrator to train its own employees, Knorr-Bremse will also be able to offer its direct and indirect business partners – such as operators, vehicle manufacturers, licensing authorities and independent validators – the opportunity to use the CT² to familiarize their personnel with a wide range of rail vehicle braking system functions. Individual training can be carried out on the demonstrator without a vehicle having to be made available.

Training on the actual equipment used in the field

The Air Supply business's successful expansion of its maintenance and overhaul training portfolio over the past few years is another textbook example of the philosophy that underpins the entire RailServices training program. Training is available on all the relevant original equipment types for virtually all of the vehicle's air supply system. The fundamental aim is to provide participants with training conditions that are as realistic as possible. Instead of practicing on specially prepared training equipment, the participants get to work on standard equipment that has been used in the field.

The main training content covers disassembly, assessment of component reusability, reworking, reassembly and final inspection. Updates, upgrades and new products are also incorporated into the program on an ongoing basis. The ultimate goal is to ensure a reliable process for returning equipment to a condition that is functionally as good as new, even after multiple overhauls. If necessary, advanced Knorr-Bremse employees with experience can also be trained as trainers.

▲ The correct way to measure braking force is demonstrated during practical training

▲ CT² air brake system demonstrator

On track in Oslo

Sophisticated technology and tried-and-tested monitoring functions: Knorr-Bremse contributes to a major project in the Norwegian capital by supplying sanding systems to an existing LRV platform.

Sometimes a picture speaks a thousand words. A simple visual comparison illustrates the size of an order received for the expansion of Oslo's urban transportation network: If the 87 new light rail vehicles being supplied by Spanish manufacturer Construcciones y Auxiliar de Ferrocarriles (CAF) from its Urbos 3 platform were lined up end-to-end, they would stretch for almost three kilometers – some 50% further than the existing rolling stock.

Established LRV system solution using mini-compressors

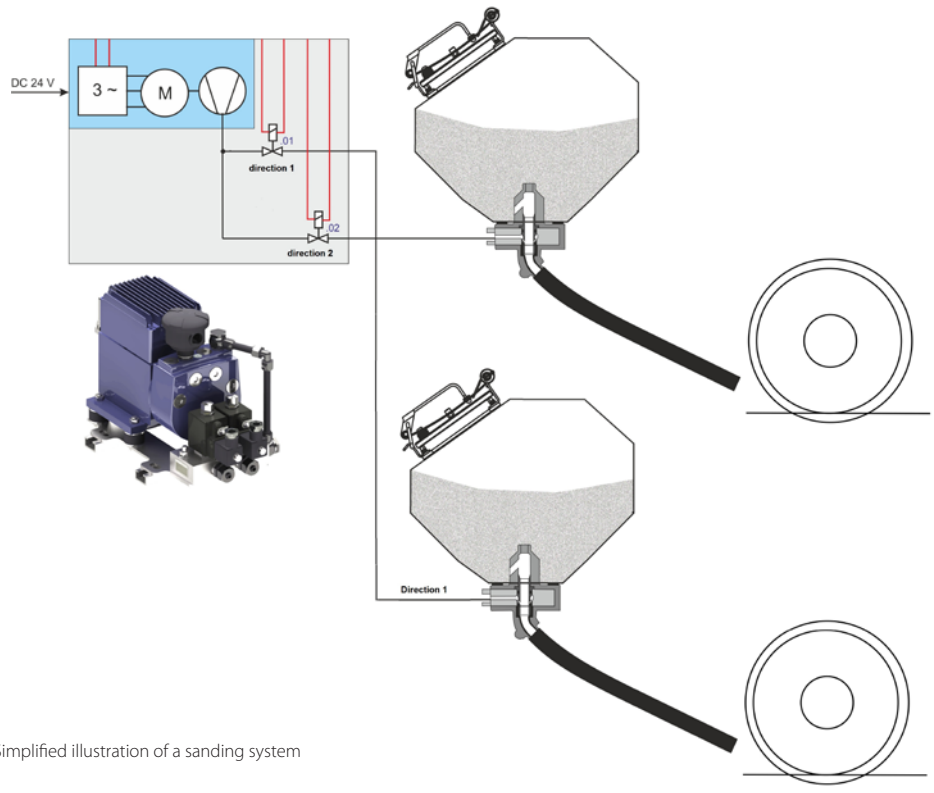
In placing the order, operator Sporveien put particular emphasis on the specifications for the vehicles' sanding systems. In a city like Oslo, where public transport plays such an important role, it was essential for the LRVs to operate smoothly – which meant that each vehicle needed a large number of sanded axles, and monitoring of their operation was also required.

This was where Knorr-Bremse's sanding systems came into their own, allowing seamless integration into the existing vehicle platform. Hydraulically braked LRVs do not have a central compressed air system to supply the sanders, so Knorr-Bremse resorted to a tried-and-tested solution using mini-compressors.

Condition monitoring using sand delivery sensors

The compressors are continuously monitored using an error output signal system – precisely the kind of condition monitoring that the operator required. Sporveien also wanted reliable sand flow monitoring, and Knorr-Bremse suggested the type of sand delivery sensor of which more than 2,500 were already in use by the S-Bahn urban rail system in Berlin.

The operator expects to take delivery of the first new LRVs in 2020. As the fleet expands, the older vehicles will then be phased out. In addition to a confirmed order for 87 vehicles, Sporveien has taken out an option on a further 60.



Simplified illustration of a sanding system

products + services

Deceleration control system significantly reduces braking distance variation

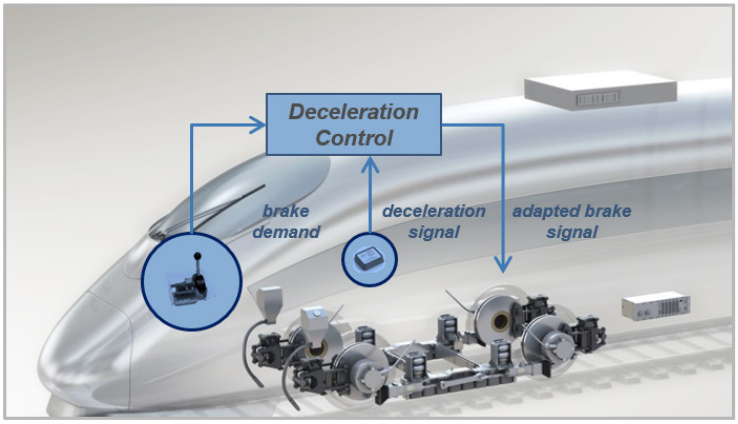
Knorr-Bremse has applied to the Polish Office of Rail Transportation (UTK) for authorization to fit a three-car regional multiple unit with an innovative deceleration control system that enables significantly more consistent braking performance at all speeds.

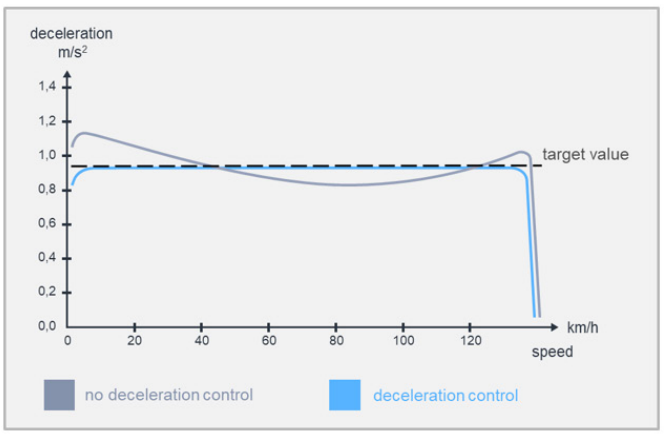
Under ideal conditions, if a train has to brake suddenly or perform an emergency stop, the braking system generates a consistent, load-dependent emergency brake pressure on all the wheelsets. In principle, this means that the braking distance before the train comes to a halt should always be the same, since exactly the same braking force is always applied to the wheels.

In the real world, however, vehicles never operate under ideal conditions. The friction coefficient of the brake pad and brake disc pairing is usually subject to variation, depending typically on the temperature of the disc, which is influenced by the drive profile prior to the braking event. Brake actuator efficiency and imprecise diameter measurements for worn wheels can also significantly affect tolerances. The combined effect of these factors can cause substantial variation in braking distances.

Decoupling braking distance from variability in operating conditions

Tolerances are factored into the design of braking systems to make sure that the train always comes to a halt within the maximum permitted braking distance, even under the most adverse conditions. Thanks to its innovative electronic deceleration con-





▲ Theoretical and operating principles of a deceleration control system

The NEWAG Impuls 36WEa three-car test train on the IK test track near Żmigród

trol system, Knorr-Bremse has been able to significantly reduce braking distance variation. This means that braking distances remain within the prescribed parameters largely regardless of outside conditions and the brake pads' friction behavior.

Each car in the train is fitted with a deceleration sensor that constantly measures actual longitudinal acceleration. The measurements are sent to the central brake control unit via the train bus, so that the deceleration control system integrated into the brake control path is supplied with real-time information about the actual effect of the applied braking force. "The deceleration control system minimizes the difference between the measured deceleration and the reference value for the train's required degree of deceleration," explains Head of Development Ulf Friesen.

The control system encompasses both the service and emergency brakes and affects all the active pneumatic and electrodynamic brakes in both brake types. The system applies the brakes according to the required degree of deceleration, taking into account current speed, outside conditions, track gradient, vehicle and car parameters and the performance of the friction material. "This means that actual deceleration is to a large extent decoupled from variability in vehicle operating conditions and tolerances," explains Friesen.

Consequently, the system has a range of application scenarios wherever braking needs to be controlled as precisely as possible – from automated driving functions to fully-fledged driverless systems or routes with platform screen door systems.

Braking distance variation also reduced by up to 85% for emergency brakes

An application for authorization of a three-car Impuls 36WEa multiple unit train manufactured by Polish company NEWAG and fitted with the deceleration control system has been submitted to the Polish Office of Rail Transportation, Urząd Transportu Kolejowego (UTK). The extremely high braking distance reproducibility was confirmed by an extensive testing and authorization program carried out on empty vehicles and vehicles with normal and maximum loads, as well as ones fitted with both JURID 878 and Propad P16 brake pads.

For instance, when deceleration control was activated, braking distance variation was also reduced by up to 85% for the emergency brake on a train traveling at 120 km/h. Similar results were recorded for a range of other speeds and loads. Even in the case of combined electropneumatic and electrodynamic braking, the braking distance variation was reduced by some 70%. The next step will involve a one-year field trial with passenger trains.

A quick, smooth commercial launch

Having obtained UIC and TSI certification, the new-generation KEf control valves for freight cars has already entered commercial operation. The fact that everything has gone so smoothly is at least partly due to the product homologation tests carried out in Knorr-Bremse's accredited laboratory.

A successful, proven and reliable technology, the KE valve has been used on freight cars throughout the UIC market for more than 60 years. The continuous improvements made during this period epitomize the technological progress and adaptability of the rail industry. There are now more than 500 variants of the KE control valve. While having all these different versions successfully meets the highly specific requirements of hundreds of operators, it has also resulted in huge logistical challenges and financial costs in connection with their maintenance.

Ever tougher demands with regard to parameters such as precision, leak-tightness and operating temperature range posed increasingly difficult challenges for the existing design. Moreover, every single refinement had to fit within the narrow confines of a housing first designed in 1953. As a result, Knorr-Bremse took the decision to develop the KEf – a completely new control valve generation that also provides the basis for the future digitalization of freight cars.

Full compliance with third-party lab standards

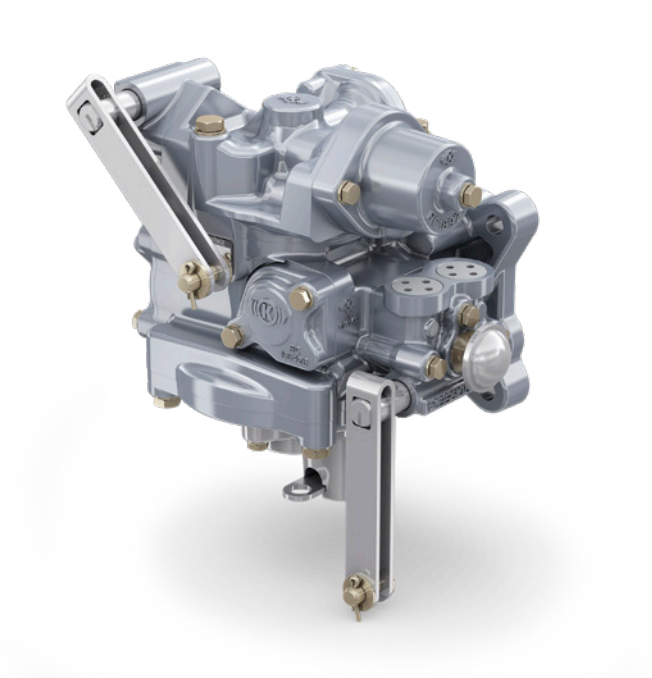
The fact that the first KEf valves have already successfully entered commercial operation is at least partly thanks to the KEf homologation tests carried out in Knorr-Bremse's ISO 17025 accredited laboratory. The accreditation and the regularly audited testing area for pneumatic control systems allow Knorr-Bremse to carry out UIC testing and reporting in compliance with international third-party lab standards. The tests were carried out under the direction of DB Systemtechnik, in accordance with the EN 15355, EN 15611 and EN 61373 standards and the relevant UIC data sheets and TSIs.

These included the simulation of a train comprising up to 80 cars on the train test rig. The vibration test rig was used to verify the mechanical stability and reliability of the valves' operation when subjected to vibration and impacts, while the tests in the climate chamber confirmed that the valves continue to function properly under extreme operating temperatures and temperature fluctuations. In addition, automated test sequences ensured that multiple repeat tests always took place under exactly the same conditions, in order to meet the requirement for full comparability of all the results.

Number of different versions cut from around 500 to 50

Whereas in previous KE generations, project-specific applications still required versions and components with different designs, with the modular KEf valves these requirements can now be met through a mechanical "adjustment range." This has allowed the number of different versions to be reduced from around 500 to just 50. The new layout means that even the standard version of the KEf can now be easily accommodated within the limited installation space of low-floor cars.

The engineers retained tried-and-tested functional principles from the existing KE valves, such as the accelerator control design and triple pressure principle. Instead of the complex, solid sand cast design, the housing parts are now formed by drop forging aluminum. As well as making the valves lighter, this has the added benefit of producing better surfaces and improving material homogeneity.



The UIC-certified KEf control valve

Maximum safety, high visibility, minimum energy consumption

Knorr-Bremse's Austrian subsidiary Zelisko is the Group's specialist for railroad signaling systems, with a safety integrity level of SIL4 – the top rating. Three major projects using LED technology recently went into operation in Romania and Finland.

Left: Shunting signal on the Riihimäki – Tampere line

Below: Main and distant signals on the Riihimäki – Tampere line (right: signal in test position)

Last summer, Zelisko fulfilled its largest ever export order for LED signals when it supplied the line between Sighisoara and Simeria in Romania – part of the important Railroad Corridor 4 linking Arad in the far west of the country, and the Black Sea city of Constanţa. The order, received from a leading systems supplier Alstom, involved Zelisko providing a total of 3,006 LEDs for the line. Prior to installation, exhaustive functional testing took place at Alstom's signaling technology CoC in Bologna, Italy.

In addition to the obvious advantages of a long operating life and high light output, the low energy consumption of LEDs played a crucial role for the first time. Their nominal power rating was 10 W – an energy saving of 50% in comparative international terms. The Zelisko engineers also succeeded in achieving the relatively high luminous intensity required with minimal degradation.

New signaling system launched without service interruption

At the end of the previous year, similar systems had already gone into operation in Finland. The Finnish railroad authority had commissioned Siemens to supply signaling technology, including all external installations, for a 110-kilometer stretch of double-track line between Riihimäki and Tampere.

Zelisko supplied a total of 2,446 LEDs for pre-, main and protection signals. A particular feature of the project was the fact that installation and functional testing of the new system was carried out without any service interruption. In order to avoid distracting locomotive drivers during the testing process, the newly installed signals were adjusted to a horizontal position, and to minimize the impact on service operations, the system was launched in five stages over successive weekends.

Finally, as part of the "Korjausvelka" project, Finnish railroad technology company Mipro equipped a number of important freight stations serving lines leading to Russia with state-of-the-art signaling technology. As usual with freight stations, marshaling operations at Niirala, Vainikkala and Kotolahti-Mussalo involve frequent shunting and require many sidings. The complex signaling systems now include 1,100 LEDs from Zelisko. In the case of signals mounted close to the ground, the company has for the first time installed heated lenses to prevent factors such as drifting snow from affecting their visibility.

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