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WHERE THE JOURNEY IS HEADING...

... with Knorr-Bremse on board

A STRONG TRIO

SNCF, Alstom and Knorr-Bremse develop the TGV of the future

CLEAN AIR Safe travel is possib

EDITION 53 July 2021 – the Customer Magazine of Knorr-Bremse Rail Vehicle Systems

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KNORR-BREMSE



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Dr. Nicolas Lange Member of the Management Board of Knorr-Bremse Systeme für Schienenfahrzeuge GmbH

Information for Knorr-Bremse's customers and business partners

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(INORR-BREMSE NEW YORK AIR BRAKE (K)) IFE (C) MERAK (I) MICROELETTRICA (IN) SELECTRON (I) KIEPE ELECTRIC (C) EVAC CO ZELISKO (C) RAILSERVICES

Dear Reader,

certain, even in these uncertain times.

One reason is the growing need for mobility in the context of urbanization and an ever more densely populated world. Another is the clear need to meet the Paris climate protection targets. But we should not deceive ourselves: There is no simple panacea that will restore passenger numbers in our sector to pre-crisis levels within weeks or months. At the same time, it is true to say that the reason that prompted rail passengers to temporarily switch to cars is now part of the solution for winning them back to rail travel: creating confidence in the safety of the air in trains.

With our patented clean[air] concept - which features among other subjects in this edition of »informer« – Knorr-Bremse is making a crucial contribution to achieving this. The approach focuses on three aspects that can be implemented on a customer-specific basis: intelligent vertical air circulation and carefully designed ventilation concepts; filtering of bacteria and particles; and effective air purification technologies. It is no coincidence that we were able to advertise this concept at such an early stage of the pandemic: Knorr-Bremse engineers had already been forging ahead with the relevant technological developments at a time when clean air in train compartments was not regarded as an important issue.

There is no doubt that the pandemic is going to change the world. But there are few indications that it will seriously undermine the current ongoing megatrends. That is why, in this edition of »informer«, we turn the spotlight on the products and systems that Knorr-Bremse has to offer in response to the megatrends of sustainability, urbanization, mobility and digitalization.

Despite the current focus on the pandemic, there is still cause to celebrate an anniversary - of course with appropriate social distancing: The 100,000th brake control unit from the CubeControl family recently went into service. Warmest congratulations to Shenzhen Metro "Line 14"! I am sure this will not be the last anniversary celebrated by this outstanding brake control system. You can read why on pages 30/31.

Stay healthy!

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Yours sincerely,
Dr. Nicolas Lange
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Knorr-Bremse Rail Vehicle Systems offers an impressive variety of customized solutions for braking and onboard systems.





WIPER / WASH

SYSTEMS



DRIVER

ASSISTANCE







SANITARY

SYSTEMS



POWER

ELECTRICS

COUPLING

SYSTEMS

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SIGNALING SYSTEMS



SOLUTIONS

DIGITAL

LIFECYCLE MANAGEMENT

ELECTRICAL SYSTEMS

Rail is – and is set to remain – an indispensable mode of transport. That much is

Expansion in Ankara

Knorr-Bremse Turkey has considerably expanded its presence in the Turkish capital, and can now offer local servicing for virtually all Knorr-Bremse braking components used in the Turkish rail market.





According to Company Manager Selçuk Sakınmaz, "the new full service center means we can offer local overhaul of virtually all of our braking systems currently used in the Turkish rail market." His management colleague Peter Karius adds: "The new service center is very close to the old site, so we can continue to employ all our highly-skilled local staff."

Knorr-Bremse St. Petersburg to open in fall 2021

You can look forward to extensive reporting packed with pictures and statements in the December edition of »informer«.

Investment in the new facility has included the acquisition of a large number of test benches, including the universal test bench for pneumatic brakes as well as benches for overhauled brake panels, calipers, block brake units and hydraulic brake calipers. "This means that before we return them to the customer, these components are subjected to exactly the same rigorous testing routines that ensure the excellent quality of Knorr-Bremse OE products," explains Sakınmaz.







Above: Knorr-Bremse Service Center, Ankara, Turkey

Center: Brake calipers are tested according to Knorr-Bremse test procedures.

Bottom right: Crankshaft overhaul was the first process to be implemented in the new service center.

Left: Brake panel overhaul and testing is a complex process.



The new facility also has a further advantage: It offers potential for assembling new units for the Turkish market as well as providing local servicing of sub-systems other than braking systems.

Team player, role model, mentor, friend



After almost 53 years' service with New York Air Brake (NYAB) and Knorr Brake Company (KBC), Ken Towns is retiring from the company.

When he started his career as a draftsman with New York Air Brake (NYAB) back in the summer of 1968, the world was a very different place: Apollo 6 – the last unmanned spacecraft to use the Saturn launch vehicle – was testing the configuration for the first manned flight to the moon, the world was celebrating the Summer Olympic Games in Mexico City, and steam locomotives could still be seen on many railroad tracks around the globe. Now – at the end of March 2021 – Ken has embarked on his well-earned retirement after almost 53 years with NYAB and Knorr Brake Company (KBC).

"Ken is the ultimate team player – a role model, mentor and friend all in one," is how Jason Connell, KBC President and CEO, sums up his respect for this father of two and grandfather of three. "Each of us stands on the shoulders of giants who blazed the trail and made much of what we take for granted possible. At KBC, Ken was a giant among giants and a gentle one at that. We all wish him and his family health, happiness and success." From the mid-1980s onwards, Ken worked in NYAB program management before relocating to KBC as Vice President of Program Management in 1994. Only a year later Ken assumed the position of Vice President of Marketing and Customer Services, and then, in 2007, he became Vice President of Contracts. Ken's impact was more than the honorable titles he held: The passion, dedication and leadership he brought to the KBC family will be greatly missed.

During his tenure at KBC, Ken faithfully walked the trail surrounding the KBC facility. In recognition of his unprecedented career, KBC has commissioned two trees and a park bench that have been placed alongside the trail, in his honor.

Under a single roof

Under the new global umbrella brand Merak, Knorr-Bremse has brought together its business activities in the field of rail vehicle heating, ventilation and air-conditioning systems.

The map of Knorr-Bremse's global HVAC network not only includes the Merak HQ in Getafe (Spain), but also Merak North America in Westminster (USA), the Merak-Jinxin joint venture in Wuxi (China), Sigma's rail HVAC technology operations in Granville (Australia), Kiepe Electric in Vienna (Austria) and, most recently, Knorr-Bremse India's HVAC activities in Palwal. And, there are all the RailServices facilities offering repair, maintenance, modernization and servicing of rail HVAC systems. In other words, a global network with local roots which has developed over the decades, offering a wide range of sales, engineering, production, logistics and rail vehicle services.

Especially over the past ten years, Knorr-Bremse had increasingly aligned the businesses of its HVAC subsidiaries and brands. And last summer the company took the next logical step by merging its global HVAC operations under the new Merak brand.

The same high standards

The underlying approach dates back at least 2,300 years and is generally ascribed to the Greek philosopher Aristotle: "The whole is greater than the sum of its parts." In terms of Knorr-Bremse's mission to ensure clean and safe air, this means: Combined expertise. Unified processes. The same high standards.

"The new brand combines the values, financial strength and advanced technology of the Knorr-Bremse Group with the global proximity, passion and expertise in air guality and climate control of over 1,600 highly-skilled professionals," says Dr. Peter Radina, who in his role as a member of the Management Board of Knorr-Bremse's Rail division is responsible for the Group's HVAC business. However, he stresses that the main focus is not so much on Knorr-Bremse itself: "Above all it is our customers who benefit from our use of common tools and processes to ensure a consistently high level of performance that is continually being improved across the entire life cycle of their vehicles."



Loco No 670, located in Amtrak headquarters in Philadelphia, successfully in use for many years and an example of impressive cooperation between engineers from Amtrak and Knorr-Bremse New York Air Brake. Equipped with MaxControl Classic (CCBII-P), the Loco has been pulling a passenger train that is equipped with the latest EE-26. fit to work with the latest North American APTA standard brake control called ECP

Covering the entire spectrum

In the field of AAR braking systems for locomotives, Knorr-Bremse is the undisputed market leader in North America. But the Munich-based specialist company also scores highly for its systems for complete trainsets. With good reason.

The North American railroad network totals some 220,000 kilometers. For decades now it has been used to carry a large proportion of domestic freight in the USA and Canada. And for a similar length of time Knorr-Bremse, with its subsidiary New York Air Brake (NYAB), has been the market leader for locomotive braking systems conforming to the AAR standard: with its MaxControl brake control platform (CCB product family). "This brake control system has been installed in more than 33,000 locomotives and control cars around the world in North America, for example, by Amtrak, IDOT (Illinois Department of Transportation) or LIRR (Long Island Rail





Merak headquarters in Getafe





Road))," reports Gregory Dalpe, Senior Vice President Sales & Marketing at NYAB. And in India it is used for Alstom Prima-E double locomotives.

Knorr-Bremse has been able to draw on the expertise it has built up over the years for the development of braking systems for complete passenger trainsets as well. Here, too, the Company is able to design customized braking systems for virtually any application.

The EE26 brake control, for example, is available for vehicle builders or operators wishing to equip their rolling stock to the APTA standard. But even beyond the APTA standard there is a wide range of configuration options that can be customized to specific requirements – for example for more advanced electronic functions in passenger cars.

The FlexControl family is also designed for controlling individual cars, whereas the MaxControl family is designed for entire trainsets, including the locomotive and cab car. "This means vehicle builders and operators in the AAR passenger car business now also have access to the wide range of Knorr-Bremse global brake control solutions," says Michael Gibbs (Deputy Director of OE Sales, Knorr Brake Company).

New equity investment

Knorr-Bremse has increased its stake in the Israeli obstacle detection startup Rail Vision. The Swiss rail operator SBB Cargo has ordered remote-controlled electro-optic obstacle detection prototype systems for its switcher locomotives.

At the end of October 2020, Knorr-Bremse acquired an additional 19.8% share in the Israeli startup Rail Vision – a company specializing in Al-based sensor technology and obstacle detection. Their systems can monitor the railroad track for up to two kilometers ahead, while detecting and classifying objects on and along the railroad track. They offer promising potential for a wide range of new applications related to automated train operations. All this marks a further step in the rapidly growing trend towards digitalization of railroad operations. "For us as a global technology leader, this makes this young company an exciting and highly attractive partner for designing rail mobility and transport solutions," says Dr. Nicolas Lange, Chairman of the Board of Management of Knorr-Bremse Systeme für Schienenfahrzeuge GmbH. For its part, Rail Vision will benefit from the Knorr-Bremse Group's global network. "Having Knorr-Bremse as a partner opens doors to projects all over the world and gives us the opportunity to develop our technology faster," says Sam Donnerstein, Executive Chairman of Rail Vision. The acquisition means that Knorr-Bremse now holds 36.8% of Rail Vision's share capital.



Prototype testing for more efficient switching operations in Switzerland

As part of a collaboration launched in 2019, a pioneering prototype project is presently running in conjunction with Swiss operator SBB Cargo. Electro-optical sensors, including a remote-control interface, have been designed to increase the efficiency of railroad switching operations with the help of articifial intelligence and deep learning. Currently, a locomotive engineer has to rely on a second person as an outside signalman to inform him by radio of possible obstacles and the remaining distance to other vehicles. Rail Vision's system enables the train to be remotely controlled by just one

Digital operation of Hamburg S-Bahn

In October 2021, trains on a German urban rail network will start operating digitally for the first time. "Digital S-Bahn Hamburg (DSH)" is a joint project being piloted by the City of Hamburg, Siemens and Deutsche Bahn. Four trains on Line S21 will operate on a highly automated basis between the stations at Berliner Tor and Bergedorf/Aumühle. On this digitalized section of the route, the driver will merely have a monitoring function, only intervening in the case of malfunctions or dangerous situations, whereas on the rest of the line he will continue to drive the train conventionally.

Knorr-Bremse subsidiary IFE is responsible for modernizing the trains' entrance systems. The background to this is the fact that automated, technology-controlled boarding and alighting processes call for the use of additional security devices in the door areas. During the required retrofit of the fleet's existing vehicles, the latest FLEX generation of door controls as well as door space monitoring and state-of-the-art automatic entrapment detection will be installed. As a system supplier IFE will provide its customers with highly competent support, and its own service engineers will be responsible for the extensive modification of the vehicles' entrance systems.





Left: Rail Vision System installed in a switching locomotive

Center: Remote control with live image transmission

Right: Obstacle detection and warning system



person, using live images and obstacle detection to continuously display in real time the distance from any obstacle. This development comes at just the right moment, as several operators are facing medium-term personnel shortages that could be mitigated by innovative digitalization of switching operations.

Orders for mass transit systems around the globe

All over the world, operators are busy expanding their fleets or replacing ageing rolling stock. Here is a selection of projects involving systems supplied by Knorr-Bremse.

Agra and Kanpur, India

The Indian megacities Agra – home of the world-famous Taj Mahal – and the industrial city of Kanpur are constructing their first metro lines. Uttar Pradesh Metro Rail Corporation (UPMRC) has ordered 67 rapid transit trains from Alstrom – formerly Bombardier Transportation – which in turn has ordered the braking and HVAC systems for the 201 vehicles from Knorr-Bremse.

Barcelona, Spain

1,680 IFE entrance systems are due to be delivered for 42 "Metropolis" trains ordered from Alstom by operator Transports Metropolitans de Barcelona (TMB). The RLS door drives are nothing new for TMB – their maintenance workshops are already familiar with them from retrofitting existing trains. The 42 five-section trains are also being fitted with Knorr-Bremse braking systems and electronic and electromechanical control components from Microelettrica.

Berlin, Germany

Knorr-Bremse has received a multi-system order from train builder Stadler Rail to equip at least 606 new metro cars for operator Berliner Verkehrsbetriebe (BVG). Since 2016, mainline trains built by Stadler Germany have been successfully operating with various Knorr-Bremse systems on board – and

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Cologne, Germany

An order for components for low-floor LRVs from Cologne's public transport operator KVB represents the biggest single supply contract ever signed by Kiepe Electric. The 64 Citadis streetcars will be manufactured by a consortium formed by Alstom and Kiepe Electric, with the latter responsible for the electrical components including a collision warning system. The hydraulic braking systems, entrance systems and HVAC technology will also be supplied by the Knorr-Bremse Group.

Moscow, Russia

Russian company CJSC Transmashholding is currently working on a prototype of new rolling stock for Moscow Metro. At the



New metro cars for the Berlin mass transit operator

now, for the first time, metro trains from the same company have been equipped with entrance systems braking systems, driver cab air-conditioning, passenger car HVAC systems, and drive switches. As part of the project, an enhanced and further developed version of the worldwide top-selling mechatronic brake control system EP2002 – now under the new product name of CubeControl – will be introduced for the first time in Germany and provide high braking reliability. The terms of the contract also stipulate that Knorr-Bremse will supply spare parts for its technologies over a period of 32 years.



turn of the year, Knorr-Bremse supplied entrance systems, the air supply, bogie equipment and the Selectron train control and management system (TCMS) with WSP for the project, which is being run by the vehicle manufacturer under the model designation 81-775, with a disc brake modification.

Paris, France

A consortium formed by Alstom and the former Bombardier Transportation for building the new MF19 trains for Paris Metro is to use up to 20 percent recycled materials. LED lighting and brake energy recuperation will also save a similar percentage of energy compared with the previous generation of trains. And some 98 percent of the trains will be recyclable at the end of their operating life. Knorr-Bremse is supplying brake control and air supply systems, as well as entrance systems for the first 44 trains of this new "green" metro.

Beijing, China

In the Company's biggest ever multi-system order in China, Knorr-Bremse is to supply Chinese train producer CRRC with braking and entrance systems for Beijing's new metro line 17, as well as heating, ventilation and HVAC systems for line 19. In total, Knorr-Bremse will deliver systems for 78 trainsets with altogether 624 cars to CRRC subsidiaries Changchun Railway Vehicles and Sifang in Qingdao.

Perth, Australia

Knorr-Bremse is supplying braking, entrance, HVAC and sanding systems for 43 Alstom multiple units – a total of 252 cars – ordered by METRONET Perth. Starting in the second quarter of 2022, EMU vehicles will be entering as urban mass transit trains within Perth and DMUs as regional trains operating from Perth and Bunbury, 170 km to the south. One important project requirement is that the trains have a 50 percent Western Australian local content. Knorr-Bremse's site in Welshpool, near Alstom's Perth facility, will play a supporting role in Alstom's delivery of the project.

Tashkent, Uzbekistan

Following an initial call-off in 2018, Knorr-Bremse is now equipping ten more four-car trains for Tashkent Metro with air supply and tread brake units, entrance and other subsystems. The trains are based on the Metrowagonmash 765 platform, which already operates, for example, in Moscow and Baku. In addition to air supply, tread brake units and entrance systems, the Selectron train control and management system (TCMS) with WSP and power electric components from Microelettrica have been customized for the platform.

Turin, Italy

With a focus on efficient urban mobility, train builder Hitachi Rail S.p.A. is designing a new LRV fleet for the streets of Turin. Knorr-Bremse will equip at least 30 new streetcars with braking, entrance, HVAC and sanding systems – and the contract contains an option for a further 40 vehicles.



Braking and entrance systems for new ICE trains

By the end of 2022, 30 new ICE high-speed trains from Siemens Mobility will be available to expand Deutsche Bahn's longdistance intercity services and several international routes. Knorr-Bremse will once again be on board with braking and entrance systems. The order for the new ICE trains is one of Deutsche Bahn's first major investments under the "Rail Pact" between the German government and the rail sector, and will play a major role in realizing the "Deutschlandtakt" vision of a synchronized rail service throughout Germany. In technological terms, the high-speed trains, which will operate at up to 320 km/h, are based on the well-established Velaro platform from Siemens Mobility. A particular feature of the trains is the eddy current brake developed by Knorr-Bremse which, combined with intelligent brake management, reduces emissions and wear. The fast-closing, pressure-tight IFE entrance systems have already proved to be some of the most reliable sub-systems in the existing "white fleet" of ICE trains.

The contract to equip the 30 ICE trains includes an option for a further 60.

Long-term cooperation

Hitachi Class 800/801/802 intercity trains are a regular sight on the UK rail network. Under a long-term service agreement with the trains' manufacturer Hitachi, Knorr-Bremse is now supplying new friction technology for more than 1,200 of these high-speed units. Starting in the first quarter of 2021, Hitachi is fitting trains, run by several UK operators, with a newly developed generation of brake pads and discs as part of scheduled brake system maintenance. The new technology will enable trains to operate with longer service intervals and reduce the time required for actual maintenance work – effectively cutting life cycle costs. Thanks to its four facilities in the UK, combined with modern RailServices logistics, Knorr-Bremse is able to offer a reliable supply of spare parts combined with rapid, efficient brake equipment remanufacturing and technical support. The contract for the supply of the new technology to Hitachi runs for four years and includes an extension for a further four.

Special retrofit solution for oil-free air supply units in the Japanese market

The demands made on sub-systems destined for the Japanese rail vehicle market are considerable. Compressors, for example, not only have to be capable of underfloor installation but must also offer interfaces that are

"ProBlock J816M" and "ProBlock J822" achieve UIC certification



In an important new step, Knorr-Bremse has extended its systems expertise in the field of brake equipment: Following UIC certification, the Company has launched volume production of the "ProBlock J816M" brake block, enabling "whisper brakes" to be provided to the OEM freight car market. In addition, the "ProBlock J822" – designed primarily for use in new-build freight cars in combination with Knorr-Bremse's Compact Freight Car Brake (CFCB) – also recently achieved UIC certification, and volume production is scheduled to compatible with the previous system. Amongst other things this means including a compressor motor controller (CMC) for the air supply unit.

Knorr-Bremse Japan, the Knorr-Bremse Air Supply Center of Competence, RailServices and Kiepe Electric have now jointly developed a package that enables compressors from another OEM to be replaced on Keikyu 1000 Series vehicles. This highly successful project was completed within a mere eight months from start to final customer approval.

Since mid-March 2020 a first vehicle has been in trouble-free operation with two oil-free VV90-T compressors and two CMCs, and an order has already been received for installation in the new Keikyu Series 1000 vehicles. Development of this system also offers initial scope for fleet operators to benefit from the advantages of an oil-free air supply.

For another Japanese customer the project team is currently developing a starter module with extended functionality, featuring an additional link to the electronic vehicle control and a diagnostic and testing function for the air supply system.

begin in the near future. This means that Knorr-Bremse is now in a position to supply appropriate brake blocks for all types of freight car both in the OE market and the aftermarket.

Compared to conventional gray cast iron blocks, the composite "ProBlock J816M" and "ProBlock J822" reduce braking noise by up to 10 dB(A) – effectively cutting the perceived noise level by half. In particular this will benefit people living in the vicinity of shunting yards and next to tracks used by freight trains.

The "ProBlock J816M" and "ProBlock J822" are both produced at Knorr-Bremse's Pamplona plant in Spain. The start of volume production of the "ProBlock J816M" marks the beginning of more product generations of composite brake pads and blocks that are already in (further) development and production.

The aim is to build up a complete portfolio of brake pads and blocks for all train types. A low-noise, low-friction brake block generation for retrofitting and modernization of freight cars, known as the "LL-block", has been on the market for some time, and Knorr-Bremse has already supplied some 3.5 million units.

Knorr-Bremse and Deutsche **Bahn cooperate** over big data



A far-reaching collaborative venture has been launched to make use of rail vehicle data captured during day-to-day operations. Under the terms of an agreement that will initially run for three years, Knorr-Bremse and Deutsche Bahn are focusing on smart data processing aimed at further improving condition-based maintenance of train sub-systems. Deutsche Bahn's aim is to improve rolling stock availability and optimize maintenance cost structures: The idea is that a rail vehicle will only go to the workshop when the condition of a system or an individual component makes this necessary.

For Knorr-Bremse RailServices, the focus is on further developing its digital and value-added services including, for example, the use of software to support condition monitoring and wear predictions, for example for door control systems in doubledecker cars. Knorr-Bremse RailServices is, of course, thinking ahead in the aftermarket business - with scalable data- and cloud-driven solutions for energy-saving, one-stop-shop repair and maintenance, parts availability and operational optimization.



Demo battery bus from Kiepe Electric in cooperation with Sileo

Bristling with state-of-the-art technologies, the 18-meter electric vehicle offers an example of a standardized platform for battery buses of 12, 18 or up to 24 meters in length. Kiepe Electric will shortly be releasing the demo bus for field testing.

"This vehicle incorporates all the concentrated expertise in e-bus system integration that our BEBPO (Battery Electric Bus Project Office) team brings together," says Jörg Gehenzig, project leader at Kiepe Electric in Düsseldorf. "It fits perfectly with Knorr-Bremse's e-mobility strategy."

The project is being jointly implemented by Salzgitter-based vehicle manufacturer Sileo, which is providing the bus body, and Kiepe Electric, which is installing the complete e-drive concept, including traction batteries and the heart of the drive system - the new, multifunctional Kiepe traction inverter (KTI). Following trials, the vehicle will be made available to potential customers for testing.

Gehenzig sees the vehicle's high charging capacity as a major advantage. "This combination of our latest technologies enables us to significantly increase opportunity/flash charging to as much as 750 kilowatts." Whereas battery buses have often required an entire night for recharging, this Kiepe Electric platform only needs a few minutes. "It opens the door for efficient alternatives to diesel buses on a 24/7 basis," explains Gehenzig. The emphasis is on operational reliability and vehicle availability.

Equipment contract for Talgo ECx passenger trains



ECx passenger train for Deutsche Bahn | © Deutsche Bahn AG

Deutsche Bahn is expanding its vehicle fleet from 2023 onwards, with an order for 23 locomotive-drawn passenger railcars and an option for a further 77. The ECx trains from Spanish manufacturer Talgo will be initially destined for the international line between Berlin and Amsterdam as well as tourist journeys from Westerland (Sylt) to Oberstdorf. Knorr-Bremse is supplying a range of sub-systems - including braking, HVAC, and entrance systems, as well as wiper/wash units - that will help reduce journey times, increase comfort and availability, and enhance accessibility.

For the braking system Talgo has opted for the EP Compact brake control, VV-270T compressors, and a customer-specific combination of steel brake discs and brake pads. The vehicles and locomotives will also be equipped with electromagnetic track brakes. Air conditioning will be provided by lightweight, compact, roof-mounted HVAC units from Merak, offering powerful, energy-efficient cooling performance even at temperatures of up to 40 °C. They are the market's first serial units designed for both conventional and natural refrigerants such as R290. With no steps to climb during boarding, the E3D-e1 door systems from Knorr-Bremse subsidiary IFE mean the ECx will set new standards of accessibility and offer all passengers greater flexibility and comfort.

"Sileo/Kiepe **Electric**" demo battery bus: charged in minutes

- Easy charging via ground current collector or pantograph The vehicles can be charged using either a ground current collector or various types of pantograph. An additional Combo-2 connector offers recharging at the depot – which means that in winter, for example, the interior heating can be run for a few minutes before the vehicle goes into service, without reducing its range at all.
- With the new demo bus, Kiepe is offering not only individual components but also a complete solution for equipping new-build buses with an e-drive system. The basic concept and technologies are designed to be modular, scalable and suitable for any make of bus. The drivable demonstrator is scheduled to enter a test phase lasting approximately six months in the second quarter of 2021. And then? "We will be happy to start showing operators what the vehicle can do in regular passenger service," says Gehenzig.

Where the journey is heading

Expanding megacities. Growing passenger numbers. Crowded platforms and trains. Developments like these call for the existing transport infrastructure to be used more effectively. Added to this is the need for even greater environmental sustainability. Here is an overview of the four central trends of sustainability, urbanization, digitalization and mobility – and the specific solutions that Knorr-Bremse and RailServices are offering.



Sustainability: eco-friendliness

The global trend towards sustainability is set to be a major factor affecting the movement of people and goods in the future. The shift from individual passenger transportation to increased use of mass transit systems is an important step towards achieving a more climate-friendly society. Smart solutions help to support sustainable freight transportation and efficient global supply chains.

Intelligent brake management enables Knorr-Bremse to prioritize wear-free, low-noise systems such as eddy current or electrodynamic braking and as a result significantly extend the life of conventional pads. Project-specific friction pairing of brake pad and brake disc also optimizes life cycle costs – to the benefit of both customer and environment. And the new generation of **organic brake pads** ("whisper brakes") is a response to increasing public pressure to reduce noise from railroad operations.

Kiepe Electric has developed a modular bridging technology that brings an era of climate-neutral trains one step closer: equipping diesel vehicles with batteries to create **e-hybrid trains**. On electrified sections of track, these trains can operate exclusively using electricity drawn from the overhead lines, achieving significant energy savings. And in particular for freight operations, Knorr-Bremse's **driver assistance system** makes an invaluable contribution to energy-efficient train operation by taking into account the schedule, route topography and – ideally – also current traffic conditions.

Energy-efficient HVAC systems from Knorr-Bremse brand Merak use up to 30 percent less energy than traditional air-conditioning units. And Merak's solutions with **eco-friendly refrigerants** can already perform at the level of conventional ones.

Urbanization: greater mobility for more people

Whereas in 2018, some 55 percent of the world population lived in cities, the UN has calculated that by the year 2050 this will have increased to around two thirds. More and more people and goods will need to be transported, particularly in densely populated conurbations.

Where the rail infrastructure is reaching the limits of its capacity, the only option is time-consuming and expensive construction of new routes. Or alternatively: better use of the existing infrastructure. With the latter in mind, Knorr-Bremse is working on an important new development. With the **Reproducible Braking Distance (RBD) approach**, it is integrating a new system for controlling train deceleration with improved slide-protection and an optimized system of wheel-rail adhesion management along the entire length of the train. Carefully combined and coordinated, these technologies are designed to bring trains to a halt reliably and precisely, even under adverse conditions. This enables automated train operation





(ATO) to be optimized, with trains scheduled at shorter intervals – improving performance but using the existing infrastructure.

But for trains to operate this way, it is essential to have efficient boarding and disembarking at each station – and the **entrance systems** play a central role in managing passenger flows. This is where the state-of-the-art systems from Knorr-Bremse subsidiary IFE come into play, offering wide and rapidly opening and closing doors, sliding steps, ramps or gap-bridges, as well as sophisticated safety features. Additional advantages are virtually wear-free operation and greater reliability combined with significantly lower maintenance costs.

Digitalization: networked and readily available rail operations

Rising passenger numbers and efficient freight transportation

bring new challenges for vehicle manufacturers and operators. The development of automated train operations offers attractive solutions. In this context, Knorr-Bremse relies extensively on **sensor-based environment monitoring** and **obstacle detection**.

There is a clear and ongoing trend towards comprehensive management of fleets, rolling stock and systems. With the help of digital technologies, Knorr-Bremse is networking and automating its systems. Enabling products to generate and evaluate data enables new digital services to be offered in the aftermarket and fleet operations.

However, widespread digitalization and connectivity also increase the potential risk of cyber attacks on trains and fleets. Like a protective screen, **systematic cybersecurity concepts** using artificial intelligence and anomaly detection developed by Group subsidiary Selectron provide multi-layered protection against external attacks. In addition, a new, standardized Group-wide **security architecture** ensures that new systems in all Group companies are always offered optimal protection against cyber attacks.

Mobility: focusing on the passenger

Green, available – and popular. Rapid, flexible train services are in fashion – both within megacities and linking them with each other. Passenger comfort and safety are crucial factors in terms of attractiveness and immediate availability.





In the case of high-speed trains, **pressure-resistant door locks** and **smart pressure wave protection** for HVAC systems ensure a quiet and relaxed atmosphere for travelers. Especially in the context of the Covid-19 crisis, HVAC systems also play an important role in ensuring clean and safe air in train interiors, with **intelligent ventilation concepts** and **ways of separating out airborne pathogens and particles** using passive and active filters, UV light or dielectric barrier discharge systems.

A lifelong traveling companion: Knorr-Bremse RailServices As a strategic service partner, Knorr-Bremse RailServices supports vehicle builders and operators with customized service packages and comprehensive life cycle management. Rail-Services offers much more than just the usual aftermarket and modernization services:

Digital, scalable solutions based on sophisticated data models and algorithms enable system failures to be avoided (**Condition Monitoring** and **Condition Based Maintenance**) and provide a foundation for optimized maintenance, operating processes and guaranteed vehicle availability. But also when it comes to energy savings, parts availability or one-stop-shop concepts, **new types of service models** offer operators genuine added value. Its worldwide service network means RailServices can offer a rapid response at local level that is competent, uncomplicated and pragmatic – and based on Knorr-Bremse's unique "can-do" attitude.

The customer's perspective – no ifs and buts

As part of a large-scale project, Knorr-Bremse Rail Vehicle Systems has radically revised the names in its central brake component portfolio to make them more logical, intuitive and customer-oriented.

The Rail division's current portfolio contains more than 5,000 brake components. Keeping track of them is a challenge, and not just in view of the sheer number involved, but also because their names mainly date back to when they were first introduced and often consist of letters and numbers. As a first step, Knorr-Bremse has now created additional "market names" for the main brake components in its portfolio.

"With these new names we are shifting the focus from the internal logic of the development engineers to the point of view of the customer," says project leader Carina Smid, Marketing Rail. "The customer should be able to intuitively grasp from the product name what function a product or component has within the overall braking system. This new, logical approach makes it easier to find your way through our portfolio." At the same time, the new system creates the basis for a consistent nomenclature that can also be used for future products.

Functional segment, product family, differentiating features

The starting point and central focus of the new system of names was the division of the product portfolio into eight

functional segments. "Supply" includes those products that supply the brake pressure, such as compressors: "Actuation" includes mechanical brake force actuators, such as calipers and block brake units, while "Interaction" refers to the human-machine interface. The "Control" segment covers brake control and brake management products; "Adhesion" stands for sanding systems and wheel slide protection; and "Friction" for brake discs and friction material. "Couplers" stands for the couplings between trainsets and between the cars within a train, while "Comfort" comprises functions such as leveling control. To keep the product names as memorable as possible, abbreviations are used in some cases. For example "Act" for "Actuation" or "Grip" for "Adhesion".

The first part of the name indicates the product family. For piston compressors, this prefix, for example, is "Piston". Together with the segment marker "Supply", this makes up "PistonSupply". At the end comes the differentiation element: In the case of an eco-friendly, oil-free compressor, the product name would then be "PistonSupply Eco". There are a small number of exceptions: High-value brands, such as KE or DB60 control valves, have retained their product names on account of their historical significance.



LOGICAL, INTUITIVE, CUSTOMER-ORIENTED

Want an overview of the complete **Knorr-Bremse product portfolio?** No problem! Just scan the QR code.

KNORR-BREMSE



New look, new overview

Easy access at:

rail.knorr-bremse.com

The new Knorr-Bremse Rail Vehicle Systems website is now online. It focuses on the product portfolio's added value for tomorrow's rail vehicles, but also contains an entertaining magazine section.

The Rail Vehicle division originally made its name by offering solutions for brakes, doors and HVAC systems. But its product portfolio has long since expanded beyond this. Both now and in the future the world of rail-based mobility can benefit from Knorr-Bremse's huge expertise as an acknowledged specialist in power supply, highly-integrated train control systems and components – and, most recently, train couplers. The same goes for digital solutions and smart products, traffic management systems and test rigs. And of course the Knorr-Bremse world consists of much more than just an extensive product portfolio. The new website at **rail.knorr-bremse.com** brings these various worlds together, offering a new look and new overview of all that the company has to offer.

Easy access to the Knorr-Bremse Rail Vehicle Systems division

"In a few clicks you will find the content you are looking for," explains project leader Carina Smid, Marketing Rail. The main navigation bar offers rapid access under various headings such as Product Groups, Vehicle Types, Rail Division Brands or the RailServices aftermarket division. "The intuitive, user-friendly system then provides easy access to the various sub-pages." And it is arranged to ensure that the deeper you go, the more detailed the information you find. At the same time, the website functions as a springboard for accessing information on over 60 production, sales and service facilities operated by the Rail division around the globe.

On the pages related to braking system products, the recently-introduced market names focusing on their function within the braking system come into play (see article in this edition on "The customer's perspective – no ifs and buts"). The new website has been optimized for all commonly used browsers as well as for mobile devices.

Magazine section with a wide-ranging focus

All this is accompanied by an entertaining online magazine section offering interesting and compelling insights into the everyday use of Knorr-Bremse systems. According to Smid, the focus also ranges beyond the company itself: "You will enjoy 'leafing' through fascinating stories on all aspects of the world of rail vehicles!"

INFORMER RAIL VEHICLE SYSTEMS

IFE entrance system for London Underground project DTUP | © IFE

London Underground has launched a Deep Tube Upgrade Program (DTUP) for four of its seven deep-tube lines. The first 94 trains for the Piccadilly Line will be equipped with specially designed entrance systems from Knorr-Bremse subsidiary IFE. Opened in 1863, London Underground is not just the world's oldest metro system – it is also one of the busiest, with some five million passengers using its eleven lines every day, and 700,000 traveling on the Piccadilly Line alone. With their dark blue livery these are the first trains due for modernization, followed by the Bakerloo, Central and Waterloo & City lines.

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At Knorr-Bremse's IFE subsidiary, production of entrance systems is already in full swing for the first 94 new Inspiro trains from Siemens Mobility destined to replace the current 1970s rolling stock. 3,760 systems, consisting of just as many door drives and 7,144 door leaves, have been uniquely designed for London Underground.

Tunnel clearance height

a challenge for entrance systems

The challenge was the special shape of the London metro system – the narrow tunnels that have given it the nickname

of the "Tube". "The overall clearance height is very limited, which means we couldn't use standard entrance systems," explains Oliver Schmidt, Managing Director of Knorr-Bremse GmbH in Austria and responsible for the Company's global entrance systems business.

"The sharp curvature of the door leaves shows once again that we can rise to the most demanding design challenges and are capable of developing and manufacturing systems to meet unusual requirements." Even though the external sliding doors and spindle drives have had to be specially adapted, the systems encompass many proven components and are subjected to rigorous testing at IFE's facility in Kematen/Ybbs prior to delivery.

In addition to the limited height of the doors, another aspect of the entrance systems was crucial for the manufacturers. "To increase train frequency and expand capacity, it is

Designed for London's narrow tunnels

important to avoid platform delays and ensure rapid boarding and disembarking," explains Sambit Banerjee, Managing Director Rolling Stock and Customer Services at Siemens Mobility. The IFE doors have therefore been designed for maximum width. Furthermore they have a service life of 40 years – making a significant contribution to the life cycle management of the rail vehicles.

Option for a further 9,000 entrance systems

In the mid double-digit million euro range, the order received by IFE for the Piccadilly Line project is the biggest in the company's history. First deliveries are scheduled for summer 2021, with passenger operations due to start in 2024. The contract also includes options for more than 9,000 additional passenger and driver entrance systems for another 216 trains on further Underground lines.

A Strong House Hou

A new TGV is scheduled to make its high-speed debut on the French rail network in 2023. Not only is the train designed to be 97% recyclable – its carbon footprint has also been improved by 37% compared with its predecessor. And a novel approach has been adopted for its development – an Open Space involving close collaboration between SNCF, Alstom and Knorr-Bremse.

As the end customer, French national rail operator SNCF has set ambitious and trailblazing targets for the Avelia Horizon[™] high-speed train (aka TGV 2020). Seating capacity has grown by 20% without compromising on comfort or increasing the overall length of the train. In addition, its carbon footprint has improved by 37%, the cost of acquisition is 20% lower, and there has also been a 30% reduction in maintenance costs. All this is combined with greater flexibility, modularity and interoperability. No wonder SNCF calls its most sustainable high-speed train "the TGV of the Future"! The Avelia Horizon[™] is set to dominate high-speed travel in France for decades to come.

The new train is the result of an innovative form of collaboration. "In the past, a project would start with us presenting our suppliers with a specification document running to thousands of pages," says Pascal Désaunay, Technical Director, SNCF Rolling Stock Division and Project Director, TGV 2020. "This time round we just formulated seven innovation targets at the start of the project and then sat down with the suppliers to write the specifications." How could they contribute towards meeting these targets? "We want industrial partners who are prepared to join us in such a data economy system, as it offers huge potential for all concerned – suppliers and SNCF alike."

Startup atmosphere and flat hierarchies Instead of the traditional system of development engineers operating in isolation, they have all been working closely together on the Avelia Horizon[™]. At the "Plateau", as the Open Space near the Gare de Montparnasse in Paris was known, operators, design engineers and suppliers have come together as equals in an atmosphere of unprecedented openness. Samuel Perrin, OE and RailServices Tender Manager and Knorr-Bremse's central contact for Alstom and SNCF in all aspects of the braking system, describes it as "a source of inspiration that makes you proud to be involved in the project." The "Plateau's" modern, laid-back atmosphere is reminiscent of a startup, complete with coffee machine, meeting corner and bar tables around which people can congregate for informal workshops.

Maite Larraya Irigoyen, Key Account Manager at Knorr-Bremse subsidiary Merak and contact person for HVAC systems, shares Perrin's assessment . "From day one I got on very well with the people from the other companies," she says. "A completely new element was brainstorming sessions in which we didn't act as customer and suppliers but rather as colleagues on the same team. Any sense of hierarchy was quickly forgotten – we were all experts, no matter what level we operated at in our respective companies."

"It has changed the way we work," says Jean-Marc Tessier, TGV 2020 project leader at Alstom. "We have moved to a partnership-like model in which customer, design engineers and suppliers see themselves as a team." It is, of course, an approach that makes huge demands on everyone concerned. "Above all it has called for a willingness to try out a new form of collaboration, set aside traditional views of our respective companies and be open to new ideas and technological developments."

Smart monitoring and energy management

Incorporation of the latest Knorr-Bremse technologies has ensured that not just the development process but also the end product sets new standards of reliability, efficiency and comfort. The trains feature total connectivity, which not only improves communications and entertainment, but also facilitates transmission and evaluation of technical data in real time – taking train control and remote diagnostics to a whole new level. According to Jean-Marc Tessier, Knorr-Bremse has played a decisive role in meeting goals such as greater flexibility, reduced energy consumption and lower maintenance costs despite the increase in seating capacity. "Knorr-Bremse is supplying the braking and HVAC systems, which are normally very maintenance-intensive items. Achieving a drastic reduction in maintenance costs was an important step in cutting total life cycle costs." Moreover, a combination of highly efficient HVAC systems and smart energy recovery during braking means the train consumes less electricity.

Samuel Perrin, for one, would like to see this new form of open space collaboration used in future projects as well – if that were the case, he'd sign up for the TGV 2050 project straight away!

Protected inside and out. Selectron, the cybersecurity expert within the Knorr-Bremse Group, is launching new generations of products specially designed for rail vehicles. At their core is the new **Threat Detection Solution (TDS).**

Defense at all times

The mobility sector has long since realized that increased digitalization and connectivity, as well as the growing complexity of transport systems, mean there has been an increase in the potential risk of cyber attacks on fleets and individual trains. "Modern rail vehicles carry hundreds of devices such as smart controllers, switches, routers and modems - as well as wireless access points for WLAN and GSM networks," explains Strategic marketing manager Tomislav Radjenovic. All these offer potential access to cyber attackers.

The bad news from Radjenovic is: "We can never guarantee 100 percent security." But the good news is: "We can come pretty close."

Ongoing anomaly monitoring of all data traffic

Radjenovic is able to make this claim partly thanks to the new Threat Detection Solution (TDS) that is currently poised for market launch. With it, Selectron has transferred to the world of rail vehicles the sort of intrusion detection systems (IDS) that are familiar to office IT specialists. "All data traffic across the train's networks and between the train and the manufacturer and operator is monitored continuously for anomalies that might indicate a possible cyber attack," explains Radjenovic.

The new TDS comes in two versions: One is a local solution involving the trains being equipped with sensor hardware directly linked to the vehicle bus. As a non-reactive device, this can be installed in new vehicles as well as retrofitted in legacy fleets. In the case of the complete solution, monitoring is by a cloud-based machine learning model. Alert messages can be viewed on the TDS dashboard or are fed directly to the vehicle operator's Security Operations Center (SOC) or a SOC service provided by Selectron.



Ethernet switches and Ethernet router



Next generation of Ethernet switches and routers

Ethernet is now a widely-used communication technology in rail vehicles. In addition to the basic functions of components such as switches and routers, train companies also have special requirements in terms of cybersecurity, ease of maintenance, robustness and flexibility. The new generation of Selectron Ethernet switches and routers (Ethernet Consist Switch and Ethernet Train Backbone Switch) fully meets these requirements, and all versions comply with the IEC 61375 standard and its supplementary documents IEC 61375-2-5 and IEC 61375-3-4.

New family of converters

Protocol converters are used to enable different bus systems and communications protocols to interact. The simplest solution is, of course, to install devices designed specifically for the project concerned. But these have one crucial disadvantage: If operational scenarios change, a huge adaptation effort is required.

The new converter family avoids this significant drawback, enabling users to flexibly adjust numerous transmission details on their own - without having to make any changes to the converter itself.

> Promotional video



A global success story

Superlatives should be used sparingly, but this brake control system surely deserves one. Development of the CubeControl family for all rail vehicle types has been one of the rail sector's most important developments in braking technology. Even with 100,000 units already delivered, CubeControl remains as popular as ever.

In 2004, when the first CubeControl brake control unit went into service under the name of EP2002, the Knorr-Bremse engineers made technological history. The new system marked the end of a method that for decades had been solely used for braking rail vehicles. Instead of applying the braking force equally in a train car the CubeControl system applies it individually to each axle or bogie. The focus on bogies is particularly effective in terms of efficient system design, as it enables the braking process to be adjusted according to passenger weight distribution and variables like the available braking level of the traction or the friction values between wheel and rail. The number of components is also considerably lower than in conventional control systems – reducing operators' life cycle costs.

The CubeControl family is already found in well over 200 rail projects around the world

The decentralized system combines electronic and mechanical components into a single mechatronic unit that can easily be installed by the vehicle builder. External components and cabling are kept to a minimum, reducing installation effort.

The Smart Valve installed on each bogie integrates all the necessary functions for load-dependent emergency and service braking, wheel slide protection and self-testing. Instead of smart valves, two bogies have redundant gateway valve modules with a bus connection to the overall higherlevel vehicle control system. These contain a project-specific smart control system for the particular local application.

Developed and manufactured at the Knorr-Bremse site in Melksham, southern England, the Cube-Control concept set a new standard that had an immediate impact on production volumes: Within five years of market launch, systems had been sold for more than 7,000 metro vehicles worldwide. To date, there are more than 200 CubeControl projects worldwide, and the list reads like the contents page of a world atlas: Ankara, Athens, Bangkok, Beijing, Berlin, Dubai, Guangzhou, London, Los Angeles, Nanjing, New Delhi, São Paulo, Shanghai, Singapore, Stockholm. Recently, Knorr-Bremse passed a significant milestone when it delivered its 100,000th unit, destined for service on trains running on the new Shenzhen Line 14 in China.

Evolutionary system of ongoing development

CubeControl has proven itself in service around the world and the system continues to evolve to offer customers ever more features and benefits. The addition of new Ethernet specifications has opened up scope for connectivity with other systems



CubeControl unit in operation

and the use of condition-based maintenance (CBM). Brake disc temperature monitoring simulates the temperature of individual brake discs in real time, helping to avoid unnecessary speed restrictions.

WheelGrip Adapt – the wheel slide protection (WSP) algorithm that can be integrated into the system – ensures even shorter braking distances under extremely low adhesion conditions. The new deceleration control (DCC) system aligns the braking of the train in real time with the actual impact of the braking power used – and increasingly separates the braking effect from the variable conditions and tolerances of vehicle operations. However, probably the most fundamental development is a systemic one: The CubeControl family has long since ceased to be confined to metros – it is now also available for other vehicle platforms such as regional & commuter trains or high-speed trains. This means that the product philosophy of standardization combined with smart solutions such as integration of the indirect brake as a back-up is now also fully accessible to the mainline sector. Therefore the Knorr-Bremse CubeControl family offers an optimum basis for brake system performance and integration in large parts of the rail vehicle industry.



"The most modern sliding door on the market"

Knorr-Bremse subsidiary IFE has added a new product to its entrance system portfolio: the LIFEDrive system. For the first time, this has two independently-operated door leaves – offering huge advantages for tightly-scheduled metro trains.



The drive for the external sliding door is installed completely outside the vehicle frame, offering more space and greater flexibility in the interior.

If a train entrance is suddenly blocked, the impact on the smooth running of the system can be disastrous. "Passengers waiting on the platform have to move along to the next door, and those in the train waiting to disembark have to walk through the interior, only to find that the next entrance is already filled with boarding passengers," explains Hans Gold, head of IFE's "Urban" business segment.

In the case of a high-speed mainline train, the timetable probably already allows for several minutes at the platform, so an incident like this is not a major problem. But the situation is completely different for commuter metros, which operate with tight intervals of 90 seconds between trains. If a stationary train blocks the track, the next train cannot enter the station, increasing the risk of the so-called accordion effect familiar to car drivers, when constant acceleration and braking makes the flow of traffic stall apparently without reason. The impact on train scheduling is disastrous.

Ready to move off after 37 seconds, rather than 60

The new "LIFEDrive" (Linear motor IFE Drive) tackles the root of the problem – the blocked door, possibly caused by a defective switch. Instead of the conventional system with two door leaves driven as a pair, the LIFEDrive controls each leaf separately. "If necessary, passengers can still board and disembark through the remaining half of the door," explains Gold. The process may be somewhat slower, but it avoids the time-consuming walk along the platform or through the train.

IFE and Delhi Metro recently ran an experiment to quantify the effect. A metro with a disabled entrance system was put into operation and the total time required for boarding and disembarking with a single or double door leaf open was calculated. If one of the two door leaves was still in operation, the time required was 40 percent shorter than when both were blocked. In other words, the train was ready to depart within 37 seconds instead of 60 seconds.



The LIFEDrive system controls the two door leaves separately: If one fails (pictured with red LED) the other one can still open.

Modular design capable of customization

"The LIFEDrive is the most modern sliding door on the market," says Oliver Schmidt, managing director for Knorr-Bremse's global door business. "But it shouldn't be seen as a competitor for our traditional portfolio. All we have done is to expand the range on offer." The LIFEDrive developed for metros contains many modified but tried-and-tested components that are maintenance-free – which is reflected in the system's low life cycle costs: "Compared with conventional systems, LIFEDrive reduces these costs by some 31 percent over a period of

30 years." The system can also be tailored to customers' specific requirements, for example in terms of width or the optional SmartSlide function for maximum acoustic insulation.

Another important advantage of LIFEDrive is the extremely small installation envelope required: For the first time, the door drive system is installed completely outside the vehicle frame, reducing the drive-unit cross-sectional area by 32 percent from 113 to 77 cm². This offers greater flexibility in the interior and enables, for example, the installation of a passenger information display.

Technical data

Entrance width, single leaf: 650 to 800 mm Entrance width, double leaf: 1,300 to 1,600 mm Open/shut cycle: 2.5 s (+/- 0.5 s) for double-leaf entrance width of 1,400 mm

Freshair on board

In this era of Covid-19, the traveling public needs to be confident that the air on board trains is clean and safe. Highly effective HVAC technologies have already been developed and tested. Here is an overview of the three dimensions in which they work – distribution, filtration and purification – and a description of Merak's "clean[air]" concept.

In Germany alone, the first six months of 2020 saw 41 percent fewer people travel by train compared to the corresponding period in 2019. Unfortunately, there is no patent recipe to ensure that passenger numbers will return to pre-crisis levels in the near future. Many people are still afraid of contracting Covid-19 on the train and therefore prefer to travel by car.

But possibly, the very reason why people have shifted temporarily to car travel could be the clue to persuading them to return to the train: It is crucial for them to be confident that the ambient air in the train is safe to breathe. The solution consists of three elements: smart vertical air circulation and ventilation systems that supply maximum volumes of fresh air, filtering of dust particles, aerosols and bacteria, and purification using ultraviolet lamps and/or ionizing devices.

"These systems are market-proven and can be installed relatively quickly in individual vehicles and fleets," comments Fernando Hazeu, Managing Director of the Knorr-Bremse Group's HVAC specialist, Merak. "Many of the 'clean' technologies that we have developed in recent years for the CIS states, China and some Middle Eastern countries are also proving effective in combating the spread of SARS-CoV-2 and similar pathogens."

The advantage of these systems is their combination of optimized air distribution, easily upgraded or retrofitted air filters and highly efficient air purification.

First element: optimized air distribution

Merak's system of optimized air distribution combines a 3D interior air layout with a concept originally developed to

reduce the energy consumption of HVAC systems by creating a clever blend of recycled and (cool) fresh air. "But this approach can also be used to significantly improve the air quality in vehicles and compartments," says Hazeu. The ideal solution is to blow fresh air in through the ceiling and extract it through the floor of the compartment. "A vertical airflow minimizes the risk of infection for passengers sitting or standing close to each other," explains Hazeu. In the case of a more open seating layout, it avoids the danger of "bad" air being distributed across seat rows.

The system is relatively easy to install: Leading up to the 2020 Chinese New Year, within just one month, Merak engineers had upgraded 5,452 HVAC systems to this smart ventilation concept in a total of 590 Chinese high-speed trains.

Second element: upgradeable/retrofittable air filters

Market-proven multi-stage filtration solutions separate particles smaller than 30 micrometers (μ m) with an efficiency of more than 99 percent – also in aerosols that can transport SARS-CoV-2 viruses. This is comparable to the performance of special high-efficiency filters. "Our filters can usually be easily retrofitted to existing air-conditioning systems, irrespective of the manufacturer," says Hazeu. During the development of new filter types, Merak has benefited enormously from its Filter Laboratory, which came on stream in 2016.

Third element: high-efficiency air purification

Air purifiers not only separate out pathogens but also kill them. As far back as 2009, Merak installed the first HVAC systems using UV-C lamps in Russian high-speed trains – and later





in regional trains as well. Exposure to UV-C rays and dielectric barrier discharge systems are regarded as the most efficient methods of combating airborne pathogens. What's more, their impact on any morphologically similar viruses is regarded as comparable. clean[air] technology ensures optimum air quality in the train interior.

Before selecting which solution to use, it is worth looking more closely at the conditions under which the particular vehicle will operate. "Clean air requirements are as varied as the operators themselves," Hazeu points out. On local trains, a wide range of passenger behavior can be expected, whereas on long-distance trains, passengers generally spend most of the journey at their seats. Customized clean[air] solutions are available for both local and long-distance trains.

Although each of these three approaches is of benefit in its own right, the air in a train is cleaner when they are combined.

New freedom

Industrial 3D printing offers interesting new possibilities, especially for the rail vehicle industry. A feasibility study carried out by Knorr-Bremse on the use of this process for manufacturing control panels for sanding systems shows it has considerable potential.

The type of aluminum panel currently in use carries the pneumatic and electro-pneumatic sanding system control modules, which are linked to each other and the braking system itself via numerous holes and air ducts. The module is supplied from a compressed air connection, with two solenoid valves controlling the flow of air to the sanding unit, and a control nozzle serving as a measuring point. A typical setup measures almost 5,700 cm³, and the aluminum panel itself weighs some two and a half kilograms.

"The bulky design of the panels is largely dictated by the limitations of the metal-cutting manufacturing processes of milling and drilling, as well as the arrangement of the equipment in just one plane," explains Dr. Thomas Anton, Head of the Brake Control CoC at Knorr-Bremse Rail Vehicle Systems. What would happen if the design were changed by using 3D printing?

Left: Individual devices are installed on the holes in the panel, with air ducts linking them with each other and the braking system itself.

Right: 3D printing provides a new degree of freedom and creates genuinely functional units.





Feasibility study to test the idea

The new degrees of freedom offered by 3D printing could enable complex structures and filigree design. Instead of being installed on a solid control panel, the modules would be arranged on a compact framework and equipped with the relevant interfaces for the devices. "3D printing should therefore make it possible to design a much lighter and more compact control panel," explains Dr. Anton. But will this actually work in practice? A team from the Knorr-Bremse sites in Budapest and Munich tested the idea as part of a feasibility study.

"One particular feature of the newly-designed unit is that the cross-section of the ducts does not necessarily have to be round," explains Attila Metál, Manager Brake Control Integration. Keeping the cross-sectional area, the shape of the ducts could vary to some degree. "This makes it possible, for example, to run the air ducts next to each other instead of having to use different component levels, as is currently the case."

Using the Direct Metal Laser Sintering (DMLS) process with AlSi10Mg as the starting material, the test prototype "grew" from the bottom to the top with a layer thickness of 60 micrometers. It was then subjected to all the usual functional tests applied to conventionally-produced panels. "The values were virtually identical," reports CoC director Anton, and adds: "The fact that the measured values almost completely matched those of conventional panels even at the start of the feasibility study was beyond our expectations."

Up to 90 percent weight-saving

Against this background, the process would seem to be suited in principle for manufacturing the control panels, according to the CoC director. "Of course, numerous further tests would be necessary before going into full-scale production, for example, in terms of optimizing the printing



Juxtaposition of a conventional brake panel (I.) and a 3D-printed carrier (r.) illustrates the advantages of the new approach in terms of volume and weight.



A function holder

process." Although initial steps for developing a corresponding set of regulations are already underway, the current lack of a standard for the qualification of 3D printing processes and for the approval of printed components for rail vehicles is a key obstacle.

But Dr. Anton has no doubts about the usefulness of 3D printing, especially for vehicle manufacturers. Compared with conventional aluminum panels, weight-savings of up to 90 percent can be achieved. In addition, the framework allows a much more compact arrangement of the equipment – opening up attractive scenarios, for example for the limited installation envelope in low-floor vehicles or in future high-speed applications. "And we're also much faster on time-to-market with 3D printing."



Faster, better testing

Knorr-Bremse's "Reproducible Braking Distance" (RBD) project aims to significantly reduce variation in train braking distances – making an important contribution towards more efficient use of rail infrastructure. The "ATLAS" wheel/track test rig plays a crucial role in the project.



Anyone trying to develop a braking system who has plenty of time on their hands will first find a suitable experimental vehicle, install prototypes and sensors and then look round for a suitably long section of track. But who has time for all that nowadays? Another challenge is how to create reproducible testing conditions, including extreme, but plausible, weather conditions and speeds. Even just for the development and validation of prototypes, entire lengths of track have to be prepared. "Adequate field testing is time-consuming, expensive, risky – and in some cases simply not feasible," says Dr. Martin Heller, Head of Testing at Knorr-Bremse Munich.

Non-scalability of material properties makes original sizes necessary

ATLAS stands for Advanced Test Laboratory for Adhesionbased Systems. Unique to Knorr-Bremse, it provides invaluable support for the development of innovative braking systems and bogie equipment. It is thanks to ATLAS that at least a part of the time-consuming and expensive field testing process has been transferred to the laboratory – or, to be more precise, the wheel-track test rig.

The rig weighs hundreds of tons and is several stories high, with hydraulics capable of generating axle loads of up to 30 tons. Together with a rail wheelset weighing 13 tons, a 1.4 MW motor creates sufficient inertia for braking distance measurements. With the help of a second motor, electrodynamic braking of the test object – and also traction tests – can be carried out. But all this is not an end in itself. "The material properties of the wheel, track and intermediate layer are not scalable," explains Heller. "Which is why, for all types of test, it is essential to have the original dimensions and forces. So it makes sense to use our original braking units."

As the braking of a vehicle usually depends on the interaction of at least four wheelsets, the development engineers and computation experts integrate the real wheelset into their simulation calculations for an entire vehicle or trainset. Guided by the measured values of the leading real axle, the calculation also incorporates additional data from field tests, for example on traction development from wheelset to wheelset.





All this testing takes place in a climate chamber, enabling exact laboratory reproduction of variables such as wind, rain, humidity, heat and cold. Other realistic conditions affecting the rail surface can include morning dew, fog, drizzle, heavy rain, soap solution, oil, and even compacted layers of autumn leaves. "The similarity of results between the test rig and field testing has been confirmed by expert reports and calculations and subjected to repeated verification," confirms Jörg Koch, who is responsible for the test rig. Koch's specialized team of test rig engineers and metrology experts play an essential role in keeping the rig in continuous operation, even during the pandemic year of 2020.

Solutions for a rail infrastructure reaching the limits of its capacity

The ATLAS test rig really comes into its own when it comes to projects like "Reproducible Braking Distance" (RBD). Knorr-Bremse engineers have achieved a world first by integrating a new kind of deceleration control system with MG23 adaptive wheel slide protection and an automatic sanding system installed throughout the train. "The aim is to achieve a calculable degree of improved braking distance stability that will enable trains to operate at more frequent intervals," explains Ralf Furtwängler, Teamleader Functional Engineering. Knorr-Bremse sees this as a key element in increasing utilization of a rail infrastructure that is rapidly reaching the limits of its capacity, particularly in large conurbations.

The main areas of use for a wheel-track test rig are obviously optimization of wheel/track adhesion and wheel slide protection, but they are not the only ones. "It also enables us to carry out a range of other types of test that are of great importance for the technological development of rail transport," says Jörg Koch. These include, for example, rail traffic noise, brake block/wheel interaction, alternating thermal and mechanical stresses, and the influence of wheelset movement on the behavior of braking force generators during driving operations.

> Left: The test rig and testing process are subject to continuous validation. Here: Profile measurement on a wheel

Center: Brakes are tested to the limit.

Right: A high-speed camera (here: sanding) provides information that would otherwise not be accessible.

