LIEBHERR

# Transportation Systems 2016

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**Technology** Battery Cooling for Electric Buses **// p. 22**

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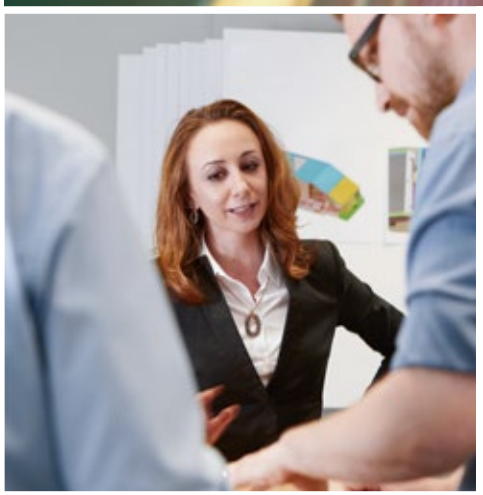

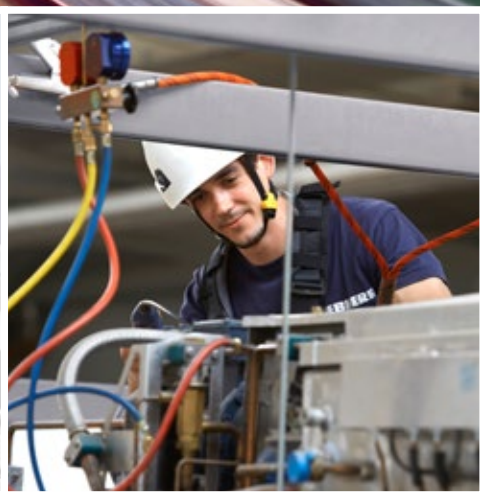

From left to right:
Adrian Gunis,
Stefan Pachowsky,
Andreas Buhl,
Dirk Junghans

# Dear reader,

The rail transportation sector is facing major challenges: On one hand, digitalization is moving inexorably into all areas of transport. On the other hand, the sector is confronted more than ever with the need to make the railway system more attractive and more competitive in the long term.

Liebherr-Transportation Systems is aware of these changes and is therefore consistently committed to innovation, especially in the areas of environmental protection, modularization and energy efficiency. You will find plenty of articles about these topics in this magazine which we hope you will find interesting.

We are continuously investing in the development of environmentally friendly cooling technologies. The newly designed air cycle air conditioning system for the ICE 3.1 of the Deutsche Bahn (DB) provides clear evidence of our commitment. So far, two trains have been fitted with air cycle air conditioning systems made by Liebherr as part of DB's Redesign Program. We are also particularly proud of the fact that more operators, such as SNCF, are interested in our Air Cycle Technology. For its "Eco-Clim" research program, the French state railway company has installed a demonstrator air cycle air conditioning system developed by us in a train that is operated in the Languedoc-Roussillon Midi-Pyrénées region. The system has so far successfully proved itself in passenger operation.

With the MACS 8.0 modular system, Liebherr will be presenting for the first time a completely new approach to the standardization of air conditioning systems for metros, trams and suburban railways. The design appeals not only because of its very low installation height and minimized weight – it also makes the HVAC system extremely flexible and guarantees a hitherto unknown availability of the air conditioning system in service.

Alongside air conditioning technology, our hydraulic actuation systems product line has developed very dynamically. Liebherr has been able to further increase its market share in this sector and gain new pioneering orders with renowned customers all over the world. In spring 2016, for example, we were commissioned by Siemens to supply hydraulic springs which will be used in municipal trams in San Francisco. In order to continue to meet our high quality standards, we have also invested in a new test facility for hydraulic systems at our Korneuburg location, which will cover all relevant test procedures.

We have also been able to expand the scope of our customer services activities. Liebherr is, for example, increasingly being asked to improve the energy efficiency of existing systems – which very clearly reflects the great faith our customers have in Liebherr services and with which we are delighted.

In our research and development work, in production, in global sales or customer services – without our dedicated employees in all areas of the company, none of the successes mentioned here would have been possible. We therefore feel that it is particularly important to provide you in this magazine with insights into the daily work of our specialists which we hope you find fascinating.

Enjoy reading our magazine.

Best wishes,

Andreas Buhl
Managing Director,
Head of Research and Technology

Adrian Gunis
Managing Director,
Head of Production and Supply Chain

Dirk Junghans
Managing Director,
Head of Sales, Marketing & Customer Service

Stefan Pachowsky
Managing Director,
Head of Finance and Administration


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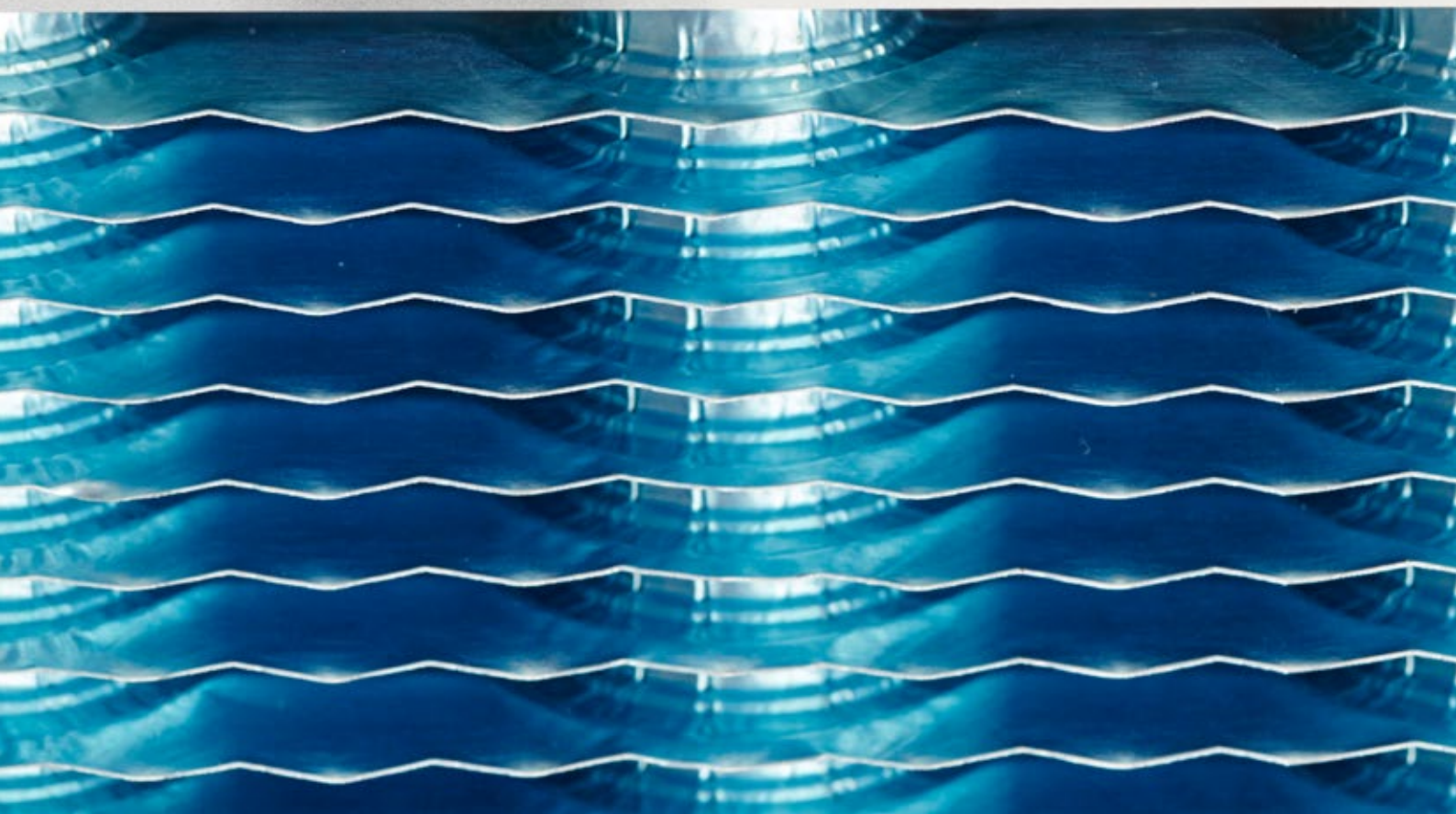
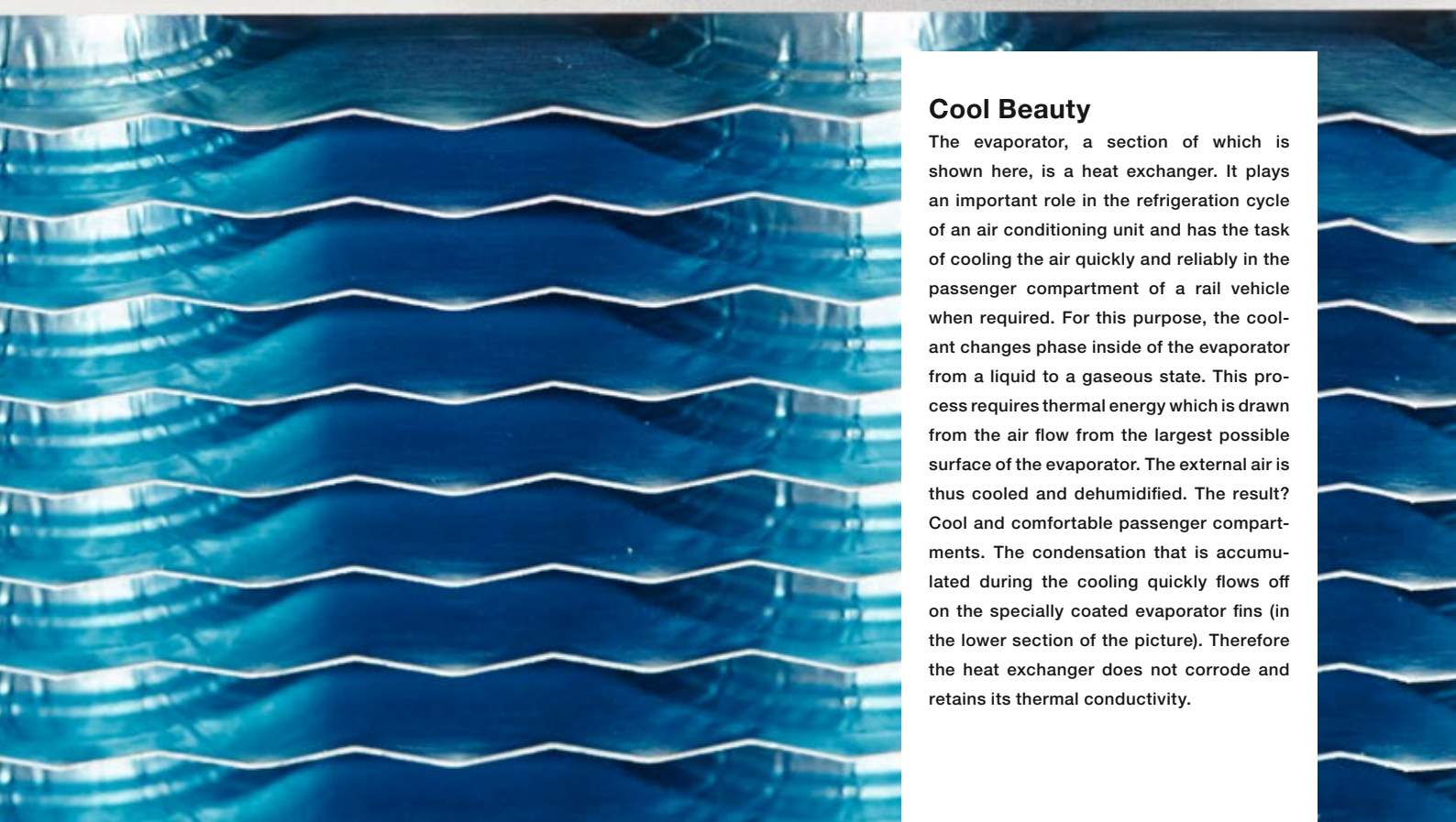




## Cool Beauty

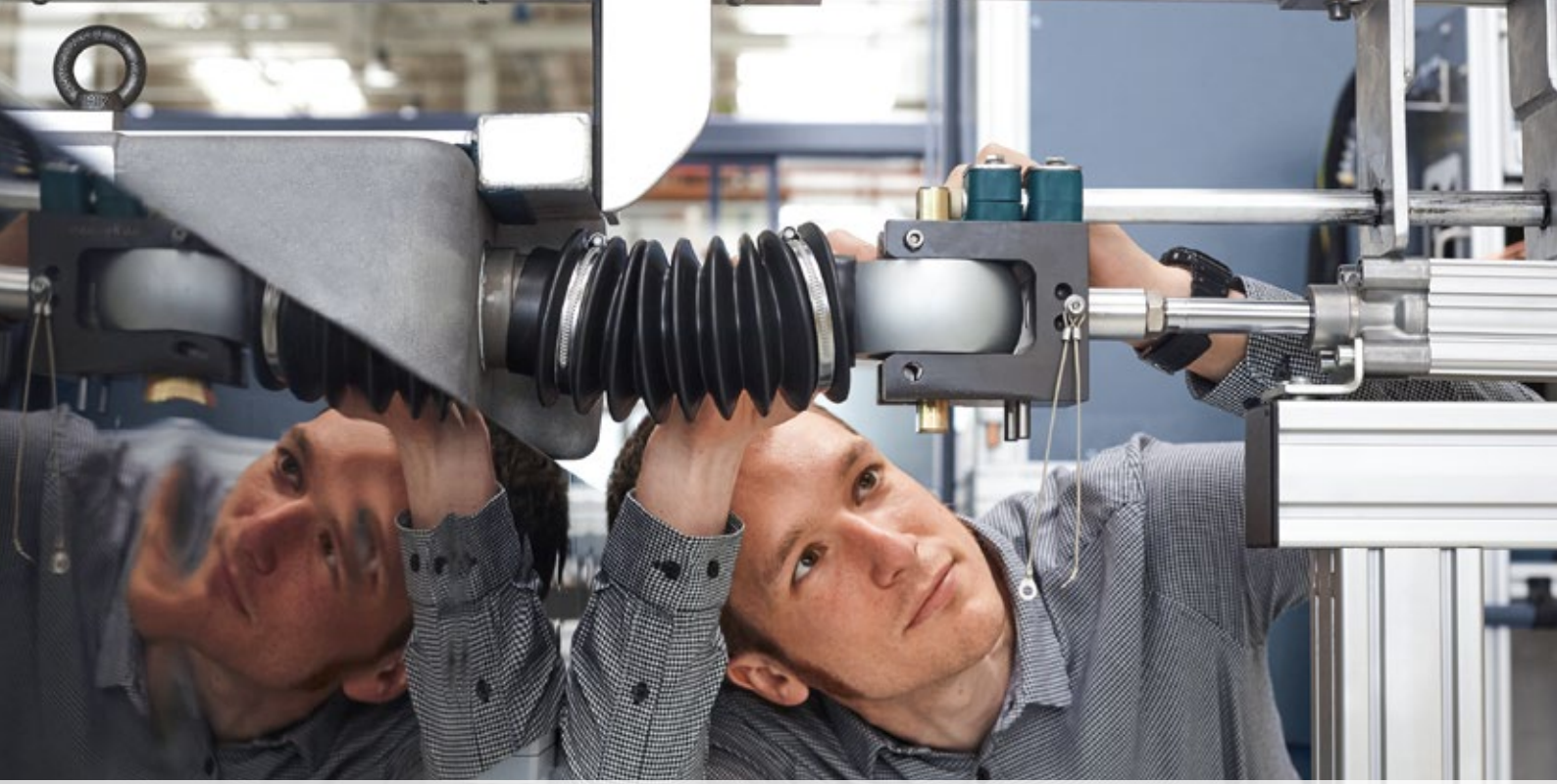
The evaporator, a section of which is shown here, is a heat exchanger. It plays an important role in the refrigeration cycle of an air conditioning unit and has the task of cooling the air quickly and reliably in the passenger compartment of a rail vehicle when required. For this purpose, the coolant changes phase inside of the evaporator from a liquid to a gaseous state. This process requires thermal energy which is drawn from the air flow from the largest possible surface of the evaporator. The external air is thus cooled and dehumidified. The result? Cool and comfortable passenger compartments. The condensation that is accumulated during the cooling quickly flows off on the specially coated evaporator fins (in the lower section of the picture). Therefore the heat exchanger does not corrode and retains its thermal conductivity.

## Constant Resistance

During maintenance, employees of Liebherr-Transportation Systems subject their customers' air conditioning systems to a thorough quality check. Here, the electrical resistance of a heater matrix is measured. In the event that the resistance is much lower than at the start of operation, this generally indicates decreasing efficiency. One possible reason (for example) is absorption of moisture by elements of the heater matrix over time which then become less effective. If this is detected during inspection, the coils in question are replaced.

## Extremely Resilient

Liebherr-Transportation Systems expose all components to extreme loads in several test runs in order to ensure reliable operating in everyday service. In the company's own 5 m long, 2.5 m wide and 8 m high air conditioning test chamber, individual components are tested to demonstrate, for example, their thermal durability. Depending on the purpose of the test, the units are exposed to temperatures between plus 60 °C and minus 40 °C for hours or days and during this process specialist test engineers monitor the behavior of the materials and functions under various conditions. In the example pictured, an engineer is spraying the cover of an air conditioning unit with water vapor in order test that the air openings do not get blocked when operating in freezing fog ambient conditions.



# Sites

## New Test Systems for Future Quality Requirements

**Extreme and rapidly changing temperatures, high speeds, tight bends – heating, ventilation and air conditioning systems and hydraulic components for rail vehicles must reliably achieve peak performances under continuous loads. The technology is therefore tested thoroughly before it is used on the rails. In this regard the innovative verification test stand engineered by Liebherr-Transportation Systems GmbH & Co KG opens up new dimensions.**

An electro-hydraulic actuator is prepared for testing.

This is a real challenge: At an outside temperature of minus 20 °C , for example, a train enters the Gotthard Tunnel where temperatures of up to 50 °C can be experienced. The air conditioning system must change immediately from heating to cooling, or else the climate comfort inside the carriages and the driver's cab suffers. The fluctuation tolerances acceptable to customers and allowable according to statutory standards are shrinking continually. A few years ago, deviations of up to 2 °C from a specified temperature were allowed, now the range of tolerance lies at 0.3 °C. To ensure the practicality of these regulations, extensive tests and precise simulations are needed beforehand.

"Liebherr is famous for testing all newly developed and refined systems and components down to the last detail and corresponding to the actual facts. With a wide range of new test facilities we are now doing this even more

effectively", explains Rainer Kaltenbrunner, Department Manager, Hydraulics & Verification.

The new facilities include the verification test facility for hydraulic systems, which is used to test whether a new product meets the customer-specific requirements. The test facility in Korneuburg is unique by unifying a wealth of knowledge in hydraulics and experience with measuring systems. It was designed by Rainer Kaltenbrunner and his team and installed together with the complete technical infrastructure, including a hydraulic oil supply device containing a central pump unit of more than 100 m length. The new test facility is extremely versatile: It can be used to test more than 80% of all hydraulic products built by Liebherr ranging from active yaw dampers which ensure a low-wear wheel run on the rail, to tilting technology for fast cornering, to leveling systems which improve vehicle access from the platform. "Internally, we use the verification test facility for development tests and externally for our customers. If they, for example, require modifications or additions, we can respond quickly and evaluate measures in advance, before they are implemented", says Kaltenbrunner.

The Korneuburg plant has a total of seven test facilities and three test benches available for series testing, verification and service inspections. The company is constantly investing in new equipment and modernization, for example the two air conditioning chambers that are able to automatically carry out overnight tests. Every improvement is aimed at making measurement procedures more precise and, at the same time, simpler and more versatile, says Kaltenbrunner. This has been achieved with the verification test facility in Korneuburg. The control and measurement system developed for this test facility, as well as the operating system, are being gradually transferred to the entire plant, after a thorough total cost of testing analysis. This means: a hardware control system that makes operating the test facilities easier for all employees plus a standardized software basis which links all departments within Production, from Pre-Development, to Verification to Series Testing. In this way, Liebherr can build up great expertise when it comes to testing.

**In Korneuburg, Liebherr is developing hydraulics systems which ensure low-wear wheel running in trains, for example, and fast cornering using tilting technology.**

# Networking in the Middle Kingdom

**Zhejiang Liebherr Zhongche Transportation Systems Co., Ltd. in the south-east of China develops, produces and services air conditioning technology and hydraulic actuation systems for all types of rail vehicles. The joint venture between Liebherr-Transportation Systems GmbH & Co KG (70%) from Korneuburg in Austria and Guangzhou Zhongche Railway Vehicles Equipment Joint-Stock Co., Ltd. (30%) was established in 2007 and is equipped for serial manufacture of goods, particularly for the large number of metro cars in China.**

“Here, we have the possibility to adapt precisely to the particular characteristics of the Chinese market”, says Dr. Yuan Lue, the company’s Managing Director. In comparison with European air conditioning technology, the heating, ventilation and air conditioning (HVAC) systems for Chinese vehicle manufacturers tend to be slightly more simple, and perhaps more standardized. Therefore, development always takes place in close cooperation with the customer before the equipment, after extensive tests, goes into series production. It is a major advantage during design if engineers can fall back on “proven design” – the transfer of expertise from Korneuburg often provides crucial design verification, plus time and cost savings.

Since 2007, Zheijang Liebherr Zhongche Transportation Systems Co., Ltd. has been the lynchpin for Liebherr activities for Chinese manufacturers and operators of rail vehicles.

In the area of hydraulic actuation systems, the joint venture is able to make use of Liebherr’s portfolio, which ranges from simple passive dampers to complex safety systems. “As a rule, we conduct the project planning, purchase the core components in Europe and adapt them to the customer’s specific requirements here”, explains Lue. If new developments are in demand, these are carried out in close cooperation between the development engineers in China and the specialists in Korneuburg.

Lue ascribes the fact that more and more Chinese vehicle manufacturers are among the regular customers of Zhejiang Liebherr Zhongche Transportation Systems Co., Ltd. to more than just the high quality of the products, which the customers have already confirmed. One of the major advantages is our advanced distribution network and the fact that the needs of the Chinese market are consistently taken into account. “Both of the companies involved in the joint venture contribute their own individual know-how: Liebherr not only uses cutting-edge production techniques but is also highly regarded as an innovative company among vehicle manufacturers in China”, explains Lue. “The Chinese shareholders, in turn, are highly familiar with the domestic market with its particular regional characteristics and business practices, which is essential for a company like ours. Together, we have now been able to attain a market share in China of 20%.”

Because Chinese customers request mainly small build programs, the joint venture has arranged its production processes accordingly. The workforce does not work on long conveyor belts; instead, flexible teams work on small production islands, which can easily be adapted to the requirements of a new series build. National customs are also very important for customer service in China: Whereas in Europe people ask for support when a problem appears, Chinese companies usually provide staff for the two- or three-year warranty period who will be responsible on the customer’s premises for keeping operations going and guaranteeing maintenance.

Being able to supply products to the highest quality standards is a further maxim for Lue, which makes a major contribution to the success of the company. Before being delivered, every single piece of equipment is therefore thoroughly tested. For example, seals are tested in a rain simulator. While these tests are running in the company's own test chamber, a series of tests on, for instance, electromagnetic compatibility, are carried out in a national institute, which provides the appropriate laboratory environment. Ultimately, all products that leave the company comply with all applicable Chinese and European standards. Engineering and production processes at the highest level, test chambers that comply with all standards – strengths like these have led to the certification of Zhejiang Liebherr Zhongche Transportation Systems Co., Ltd. according to the International Railway Industry Standard (IRIS).

"However, it has only been possible to achieve all of this because, with our 130 employees on site, we have a highly motivated and loyal team. We greatly value the commitment of our workforce. Here, local and international experts work hand in hand – which is what accounts for a great deal of our performance capability", says Lue, who looks ahead confidently. "Zhejiang Liebherr Zhongche Transportation Systems Co., Ltd. is on the right track. One of the next steps will be to steadily expand our sales activities yet further in the medium to long term."


**The warehouse in Zhejiang is well stocked.**

**Production islands instead of conveyor belts: in this way, the company can react quickly to new requirements or small series requests.**

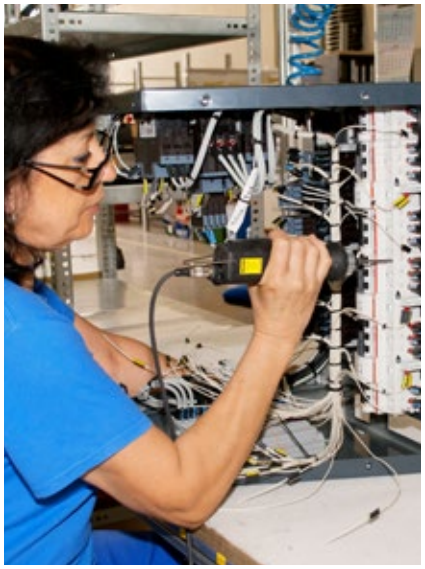
# Series-Manufactured HVAC Systems from Bulgaria

**Liebherr-Transportation Systems Marica EOOD in Radinovo (Bulgaria) will be taking over the complete series manufacture of heating, ventilation and air conditioning (HVAC) systems in the future. Thus, the site, which covers some 10,000 m² in total and currently employs a workforce of more than 270, is continuously growing and developing – always in close cooperation with Liebherr-Transportation Systems GmbH & Co KG in Korneuburg (Austria). Adrian Gunis, Managing Director Operations of both companies and head of Production and Supply Chain for Liebherr-Transportation Systems, was interviewed about current developments, activities and goals.**

**Mr. Gunis, how has Liebherr-Transportation Systems developed at the Marica plant?**
In 2004, there were only seven people on an area covering about 300 m². At that time, we were still housed in the factory of Liebherr-Hausgeräte Marica EOOD, founded in 1999, where we had a little corner, as it were. This is where production started for us in Bulgaria, always with the prime objective of remaining competitive for our customers. In the years that followed, we have gradually built and expanded our own location. In 2010, an independent Liebherr production company was established in Bulgaria, Liebherr-Transportation Systems Marica EOOD, and two years later, it had already grown into a factory area of just under 10,000 m².

**What are current activities and developments?**
Last year, the decision was made to incorporate an additional area for the expansion of transport technology activities in Marica. From fall 2016 on, we will be expanding our production step by step over a further 1,500 m² of rented space. Our strategy is to further expand Bulgaria as a competence center for the series manufacture of HVAC systems. This means that all heating, air conditioning and ventilation systems from small to large capacity will be henceforth manufactured in Marica – for example in this year around 2,440 units.

**The Marica site is continuing to develop further, and its area of roughly 10,000 m² allows plenty of space for future activities.**



**Production of around 2,440 heating, ventilation and air conditioning (HVAC) systems in Marica in 2016 alone.**

In 2015, we moved all hydraulic actuation systems programs for repair and series production to Korneuburg. Subsequently, in Korneuburg, we are able to concentrate on the series manufacture of hydraulic actuation systems and, at the same time, further expand the spare parts business for the HVAC and hydraulic actuation systems product lines as well as our repair and maintenance activities. Thus, the Korneuburg site is our center of competence for the development of HVAC units and hydraulic actuation systems as well as for the series production of hydraulic actuation systems.

**How would you describe the cooperation between Korneuburg and Marica?**

Even if these are two independent companies in Austria and Bulgaria, I personally believe that they operate as one unit. After all, in Korneuburg, the complete development including prototype production of HVAC systems is carried out. Project management, distribution and customer services are also based there, while series manufacture will be run solely in Marica in the future. So essentially, one large, cross-border team is working here.

**Against this background, what does your working day look like?**

As Managing Director Operations in Korneuburg and Managing Director of Marica, I am responsible for production, strategic purchasing and logistics. On the whole, I control things from the Korneuburg site, with a close and daily contact with Marica, of course. I am personally in Bulgaria at least once a month.

**What opportunities and challenges do you see for the upcoming years at the Bulgarian site?**

More responsibility also involves more tasks. We must also use the know-how in series manufacture we have built up in recent years. We will be increasing and expanding our expertise even more quickly and more widely. In the past, for example, projects were prepared completely from Korneuburg, including work preparation and setting up the manufacturing lines, which were then taken over by Marica. In future, we will be handling these tasks, that is the planning of necessary tools and equipment and everything included, increasingly in Bulgaria. We now also have a strategic purchaser at the Bulgarian site and schedule HVAC material for Korneuburg. Activities are also getting more complex. In 2009, Liebherr-Transportation Systems Marica EOOD obtained IRIS certification; in 2014, we were also certified according to ISO 14001 and OHSAS 18001. That shows how positively and successfully this location is developing. We will be linking up even more, for example by integrating the Bulgarian location and the manufacturing expertise of our employees right into the development phase of HVAC systems. In this way, we will also make series manufacturing as efficient and reliable as possible for our customers.

# Long-Term Customer Loyalty with Service Center in Gatwick

**Railway business in the Greater London area is constantly increasing, and this has also been the case at the service center of Liebherr-Transportation Systems in Gatwick since its opening in 2014. Specialized in the maintenance, repair, overhaul, commissioning and testing of heating, ventilation and air conditioning systems (HVAC) for different railway companies, the delivery of materials, as well as support and training for customers, the performance of the team on site is characterized by high service standards and unwavering commitment.**

The first major task in the 900 $m^2$ Liebherr service center was the overhaul of HVAC systems fitted to Class 159 trains for the Wabtec Rail Group for which the company recently finished the first three train sets. This complex job was completed exactly in accordance with time, scale and quality stipulations. With outstanding expertise in the field of air conditioning systems, the Liebherr-Transportation Systems office in Gatwick supports its customers with smart and predictive maintenance. By examining the equipment on a regular basis, the specialists are not only able to see trends and propose improvements but they can also carry out changes directly and offer optimal systems and solutions. As a key performance of the center, five service technicians take turns on the 24/7 customer hotline to help and directly provide support in case of emergencies. The approach that is followed by the maintenance center is not only to be a mere supplier of warranty services, but also to build a successful long-term partnership with customers.

In this context the proactive step of Liebherr to locate in close proximity to the main train service depot of Siemens was crucial for the cooperation recently started with Thameslink: For an initial period of ten years, Liebherr-Transportation Systems was appointed by Siemens to provide maintenance and support services for HVAC systems of Thameslink's Class 700 fleet which consists of 115 trains with 1,140 cars. Engineers at Liebherr-Transportation Systems and Siemens will be working together to further improve, develop and refine the service scope, as well as methods and periodicity. This is to ensure the most effective maintenance processes as well as highest levels of passenger comfort. "The maintenance carried out by true specialists adds value for the customer. Our job is to keep the passengers comfortable on long train journeys, so our mission is to further improve the air conditioning system", commented Alan LePatourel, UK Sales Director at Liebherr-Transportation Systems. To that purpose an initial personal meeting took place in order to draw up the customer's perfect scenario in a roadmap. Adhering to this, Liebherr focuses very closely on the requirements of the customer and subsequently plans and implements measures to achieve this scope of work.

The service center in Gatwick is also preparing for the recently signed contract with Arriva TrainCare in Cheshire (UK). Liebherr-Transportation Systems were selected to retrofit 35 Class 158 regional express trains with HVAC systems. The company will

also overhaul and modernize eight cars already equipped with Liebherr HVAC systems. The challenge here is a very tight time schedule as each operation foresees a slot of only one week, making close planning and co-operation with the partner essential. The Class 158 diesel multiple-trains are operated by Great Western Railway Ltd. on some of the busiest routes in and around the South West of England.

All collaborations contribute to the scope of systematic expansion and long-term partnership. “The best feedback we can get is if our customers continue to use and value our services”, says Alan LePatourel.


**The Liebherr service center in Gatwick has an area of around 900 m² to store material for its customers’ HVAC systems.**

**Repairing, maintaining or testing: The staff of Liebherr-Transportation Systems in the service center in Gatwick have a wide range of expertise when it comes to heating, ventilation and air conditioning systems.**

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# Programs and Contracts

## Air Cycle Technology Successful in Practice

Cold air technology, also known as air cycle technology, is currently the only environmentally friendly alternative to the air conditioning of trains using chemical refrigerants that has been tested truly in practice. Liebherr was one of the first companies to transfer the technology – originally developed for aviation – to the railways, where it has been successfully functioning in daily passenger operations for more than a decade.

The fundamental concept is to avoid the use of traditional chemical refrigerants which, if they escape into the surrounding air, have a negative effect on the atmosphere. With air cycle air conditioning systems, normal air (process air) is used for cooling. It is taken from the surrounding atmosphere and expanded with an electrically powered cooling turbine; at the same time, the temperature decreases as the air drops below atmospheric pressure. An air-to-air heat exchanger then brings about an energy exchange with the incoming air which is then forwarded to the passenger compartment. In the open cycle of the cold air system, the process air is then compressed back to atmospheric pressure and passed back into the atmosphere.

“This process has many additional advantages apart from the outstanding ecological balance”, explains Andreas Buhl, Managing Director and Head of Research and Technology at Liebherr-Transportation Systems. “Air is everywhere. It does not need to be manufactured, stored or painstakingly disposed of after use. In addition, air is not potentially hazardous for employees in production or for passengers if the air conditioning system should leak.” Thanks to their simple design and easily replaced components, air cycle air conditioning systems also stand out because of their reliability and low operating and maintenance costs. In addition, it is also worth mentioning that cold air systems reliably cool the train compartments even if the outside temperatures are very high, while conventional designs often switch off in these conditions because of the excessive pressure that builds up in the refrigeration circuit.

**Reliable use in ICE 3**

Liebherr’s air cycle technology has been in successful operation in second-series ICE 3 trains since 2002. In spring 2015, the company supplied additional air cycle air conditioning systems for an eight-part test train to Deutsche Bahn for the redesign program for the ICE 3’s first series. In summer 2015, the train started a trial phase lasting several months in day-to-day passenger operation. The aim of the trial was to demonstrate the efficiency and reliability of the systems specifically in the hot months of July and August. The evaluation and appraisal of the collected data was completely positive. Since then, a further train set has been supplied and successfully taken into operation.

In addition, since the middle of 2015, Liebherr-Transportation Systems has been carrying out an analysis to evaluate the efficiency of air conditioning systems using natural refrigerants on behalf of the German Environment Agency (UBA) and in collaboration with DB. For this, an extensive program of measurements has been started on the cold air systems newly installed in the ICE 3.1, which will run until March 31, 2018.

The aim of the investigation is to measure the actual energy consumption of the air cycle systems over a long period of time, under real operating conditions and through all the seasons, and thus to allow realistic quantitative comparisons with conventional systems on the basis of empirical data over the entire life cycle.

**Liebherr tests its environmentally friendly air conditioning system with SNCF**

In France, a demonstrator of an air cycle air conditioning system developed by Liebherr has been undergoing tests in an SNCF regional train since September 2015. The modification of the train required for the French railways' "Eco-Clim" research program was subsidized by the Midi-Pyrénées region (Southern France). The 24-month test program is intended to provide SNCF with the necessary data and measurements to be able to evaluate the advantages of the air cycle system objectively. For example, various functional parameters such as cooling output and energy consumption are compared in real operating conditions. All in all, a win-win situation: SNCF is able to specify its requirements exactly, while Liebherr-Transportation Systems can further optimize the air cycle air conditioning systems for the rail vehicles of the next generation on the basis of the results obtained.

The air cycle demonstrator was also presented to the general public in fall 2015 as part of the "Train du Climat" project. This was a special SNCF train which visited all the important cities in France on the occasion of the United Nations' 21st Climate Conference (COP21) to present the many measures that the French rail operator has introduced in order to contribute to a more environmentally sustainable rail transport system.


**An SNCF regional train has been traveling around since September 2015 demonstrating environmentally friendly air cycle technology, which uses normal air for cooling.**

# San Francisco: Hydraulic Steering Springs

The cosmopolitan city of San Francisco in the US State of California has an extensive public transport network operated by the San Francisco Municipal Transportation Agency (SFMTA), known as the “Muni”. Alongside the San Francisco trolleybus and the world-famous historic cable cars, modern trams will also be deployed in the city area. The new generation of trams is being produced by Siemens in its manufacturing hub in Sacramento (California). Important components of these trams include the upper articulation connection which is a special hydraulic spring. The manufacturer commissioned Liebherr-Transportation Systems to supply these in spring 2016. The order comprises 215 car sets, with an option for the supply of a further 45 car sets. The first upper articulation connection units were delivered in July 2016.

The hydraulic springs return the car body segments from different roll angles back to the neutral position during operation. The springs are integrated above the articulation between two adjoining car body segments. The spring force in the upper link limits wheel unloading and enhances the ride comfort in curves for passengers.


**New trams with Liebherr technology on board will be traveling the streets of San Francisco.**

# Boston: Trams with Leveling

Boston is the largest city in New England and state capital of Massachusetts on the East Coast of the United States. The city’s public local transport system consists of four subway lines, the Boston trolleybus, local bus lines and suburban railway lines. The latter fleet also including low-floor trams built by the Spanish manufacturer Construcciones y Auxiliar de Ferrocarriles, S.A. (CAF), which are operated by the Massachusetts Department of Transportation (MassDOT).

When equipping the vehicles with hydraulic actuators for leveling systems, CAF returned to its reliable partner Liebherr-Transportation Systems. CAF and Liebherr have already been cooperating in various projects of this kind since 2013. These have included metropolitan trams in Houston, Texas, and the trams in the US cities of Cincinnati, Ohio, and Kansas City, Missouri. The current order consists of 192 actuators in two different versions for a total of 24 rail vehicles. Delivery of the components is expected to start at the end of 2016 and will be completed in 2018. “We are delighted to work with CAF on this project”, says Dirk Junghans, Director Sales, Marketing and Customer Service at Liebherr-Transportation Systems GmbH & Co KG. “This new order underlines our leading position in the area of hydraulic actuators in the North American market.”

The hydraulic actuators fulfil an important function, particularly with respect to accessibility: They enable the precise adjustment of the vehicle’s entrance height to the level of the platform. Passengers with restricted mobility or those with bicycles or prams are assisted greatly in boarding and leaving the vehicle.

# Wuhan: More Comfort for Urban Railway Users

Zhejiang Liebherr Zhongche Transportations Co., Ltd. is supplying the Chinese rail vehicle manufacturer Zhuzhou Electric Locomotive Co., Ltd., with 21 anti-buckling systems for its low-floor trams. The trams will be operated in the city district of Wuhan, the capital of the province of Hubei in Central China, which has a population of around 4.3 million people. The operator is the Wuhan Railway Bureau, one of the 18 nationwide companies which belong to the China Railway Corporation.

The hydraulic anti-buckling system, specially developed by Liebherr-Transportation Systems for low-floor trams, fulfills a critical safety function: It ensures that the specified clearance profile is maintained under any operating conditions. This function is monitored by a standard electronic controller which Liebherr has integrated into the system. In addition, the anti-buckling system improves the ride comfort and reduces wheel and rail wear, since the bogies are connected by a hydraulic coupling.

Zhejiang Liebherr Zhongche Transportation Systems Co., Ltd. is a joint venture of Guangzhou Zhongche Railway Vehicles Equipment Joint-Stock Co., Ltd. and Liebherr, and is based in Zhuji in the Chinese province of Zhejiang. It was established in 2007 to design and manufacture air conditioning systems and hydraulic actuation systems for rail vehicles.

# Hamburg: Air Conditioning for Underground Trains


**Liebherr's air conditioning and hot water systems ensure that the passengers in Hamburg reach their destination at the right temperature.**

Based on a contract with Bombardier Transportation, Liebherr-Transportation Systems will equip 33 DT5 underground trains with air conditioning systems and heating systems. The vehicles shuttle the passengers of Hamburger Hochbahn AG in and around the Hanseatic city. Three passenger compartment and two driver's cabin air conditioning units from Liebherr will be installed in each train. The heating systems, which utilize the waste heat from traction, are designed for the passenger compartment.

The focus of the equipment installed in the trains is on passenger comfort as the DT5 underground train is the first operated by Hamburger Hochbahn AG to offer passengers an air conditioned compartment.

This contract not only strengthens Liebherr-Transportation Systems' position as a leading supplier of air conditioning systems in Germany, but also underscores the many years of successful collaboration with Bombardier Transportation. All equipment is scheduled to have been delivered by July 2017.

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# Technology

## Reliably Cooled – for the Life of the Battery

**Whether it's electric cars, e-bikes or electric scooters – nowadays, the electric drive system is a genuine alternative. Moreover, the emission-free, low-noise drive system is also being used increasingly in local public transport. The core of such a drive system often consists of a lithium ion battery that provides the drive system with power. As the battery heats up during use, a cooling system is required – just like in a traditional car. Liebherr-Transportation Systems has developed such cooling systems for Bombardier for lithium ion batteries that provide the customer's PRIMOVE® drive system with energy. For instance, the battery cooling systems are being used in the local public transport on electric buses in Berlin and Braunschweig and electric trams in Nanjing (China).**

Cooling the lithium ion batteries extends their life expectancy because, without cooling, the battery would quickly age due to high operating temperatures during its use. The modern, lighter and efficient lithium ion batteries are relatively cost-intensive components, which is why extending their working life is particularly valuable.

The engineers at Liebherr-Transportation Systems have developed a cooling system with which lithium ion batteries can be operated at optimum thermal conditions: the system constantly keeps them within a suitable temperature range. The highly efficient cooling system has already been successfully used in a test covering around 120,000 operating hours, and is also characterized by its robust, easy-to-maintain architecture. A cooling system of this type works reliably at outside temperatures between minus 30 °C and plus 50 °C. The result: The high-performance batteries are cooled reliably with relatively little energy and can thus effectively fulfil their function.

However, the lithium ion batteries, which are a fundamental component of Bombardier's PRIMOVE® system, have to be particularly well cooled for another reason. Bombadier's inductive charging system, which has already been proved successfully in operation, makes it possible to "top up" the batteries rapidly by means of contactless charging whilst passengers are getting on and off the bus. The fully automated charging guarantees uninterrupted operation and can be embedded into the existing infrastructure seamlessly. With this very rapid energy transfer, the batteries tend to heat up again. However, with the Liebherr battery cooling system, the resulting heat is consistently removed from the battery block.

The reliable cooling systems developed by Liebherr are already on the road in electric buses of various established manufacturers in Braunschweig, Berlin and Mannheim, where they are making their contribution to reducing the $CO_2$ balance of the municipal local transport systems in the future. In China, they have been installed on board the new, virtually catenary-free trams ensuring high quality transport for millions of people in Nanjing.

# BK4: Modular Electronics for the Future

**How does a single plant and systems controller meet a wide range of requirements and flexibly cope with different project sizes at the same time? With a recently completed development project, Liebherr-Transportation Systems in Korneuburg (Austria) is presenting the solution: BK4. The modular controller system measures and controls actuators and sensors in air conditioning and hydraulic systems in different types of trains.**

BK4 is the successor to the BK3 controller which has successfully proven its value in railway technology for over ten years. The universal controller regulates air conditioning appliances and hydraulic components inside the train and is always mounted directly at the component under control. Thus one or more units are usually installed per car. The aim now was to create a new product in line with the latest developments in technology which makes sure that air conditioning and hydraulic systems in trains remain fully functional throughout their entire operating time – and at the same time can cope with different project sizes. The housing of the predecessor model integrated a processor and many individual inlets and outlets (I/Os), whereas the new control pursues a modular approach. Often, the controller system was too large for less complex projects which only require a small number of I/O modules. However, more demanding projects needed several modules that had to be installed additionally.

The modular controller system now reduces the number of empty I/O modules and includes a controller (R1) and variable I/O expansion modules (E1). “In 90 % of the projects the new solution brings lower costs and much greater flexibility to our customers – especially since the predecessor model can be replaced very easily”, states Dr. Klaus Raggl, Head of System Engineering at Liebherr-Transportation Systems. Moreover, the new electronic controller is more compact, more powerful and offers a wide range of connection options and additional functions. For example, customers are able to access the system directly via a web browser using a man-machine interface (MMI) to carry out diagnoses and maintenance.

The BK4 controller was developed in close collaboration with Liebherr-Elektronik GmbH in Lindau (Germany). In every phase of the process, strict quality criteria for reliability and functionality had to be met in order to comply with the high standards of Liebherr-Transportation Systems. “We did not merely draw up a specification with our colleagues at Liebherr-Elektronik – rather we successfully performed important development work together in order to create an integrated system”, explains Dr. Raggl.

Manufacture of the R1 and E1 components is to be completed by the end of 2016 and initial application projects in customers’ equipment are also already planned. “With the BK4 controller, we are presenting our customers with a modern solution that offers safety and cost-effectiveness in the long term”, says Klaus Raggl. “Our customers use their equipment for 30 to 40 years, thus this is particularly important.”


**Whether it’s for larger or smaller projects – the new BK4 controller has a modular structure and can thus be used anywhere.**

# Customer Service

## Service Right Down the Line

**Wolfgang Böttcher is head of customer service at Liebherr-Transportation Systems and knows his customers' needs precisely.**

**Mr. Böttcher, what are some of the typical customer inquiries that you receive?**
We work for various manufacturers and operators of rail vehicles in many different countries – and the inquiries we receive reflect this diversity. However, the responsiveness of customer service and the availability of spare parts are of the utmost importance for all our customers if they are to ensure the unrestricted operation of their vehicle fleets. In this respect, having a dense network of service support points is very helpful, of course. For example, if an air conditioning system or a hydraulic actuation system is damaged, our engineers are quickly able to attend site to assess and repair the damage. Alternatively, customers send us the faulty component or the complete system and we repair them here in Korneuburg or at one of our other service centres. Service deployments of this type need to be closely coordinated, because the operators plan the availability of their vehicles according to a precisely defined schedule. We therefore need to be able to make use of any brief time frame allocated by the client at short notice.

**How quickly are spare parts available?**
The items in stock in our spare parts stores can be delivered within Europe within 48 hours. However, we are currently working on concepts that will

**"Intelligent, tailor-made service solutions are becoming increasingly important", comments Wolfgang Böttcher.**

allow us to supply spare parts within 24 hours as a rule. This is definitely in the interest of our customers, as it means that the storage of Liebherr spare parts directly on the customer's premises can be reduced to a minimum. This saves money on storage and handling of goods. In many cases we also combine consignment stores and logistics – whatever suits the customer best.

**What do you do beyond traditional repairs?**

We train staff, such as train operators' employees, so that they can carry out simple repairs of air conditioning and hydraulics systems themselves, after the warranty period has ended. In more liberalized markets, such as the UK or Scandinavia, individual servicing packages are also popular, where we, for instance, take on the complete servicing of entire fleets for up to 15 years. In short: We aim at being a reliable service partner for our customers from commissioning of the product to the end of its working life. And we are increasingly working on projects where we are using our expertise to modernize and improve the efficiency of systems that are already operating.

**Air conditioning systems are major energy users on board. What opportunities for improvement do you offer your customers here?**

A Liebherr air conditioning system is generally designed for a working life of 30 to 40 years. Therefore, our customers specifically ask whether and how we can optimize their systems over this long period of time. We review the air conditioning equipment every ten to twelve years, usually as part of a general overhaul, and carry out technical modifications so that they use much less energy. Energy savings up to 20% and more are not uncommon. Similarly, it is also possible to increase the efficiency of older systems sustainably, especially at high outside temperatures. For this, we make use of standardized solutions that we can adapt appropriately. In projects to optimize existing systems, we work closely with our engineering team, as we did for the overhaul of air conditioning systems for Pars nova, a company of the Škoda Group, which specializes in the modernization of rail vehicles. Within this servicing project, we completely overhauled and upgraded the air conditioning technology in the passenger carriages so that they continue to work reliably even at high outside temperatures, as specified by the operator.

**Alongside repair works, Liebherr also offers its customers such services as training.**

**What will the customers expect from Liebherr-Transportation Systems Customer Services division in the future?**

Projects such as the one for Pars nova will undoubtedly continue to increase, and thus the internal cooperation between customer services, product development and production will also grow. I am assuming that services beyond traditional repair work will be more in demand. Particularly, if markets continue to open up, intelligent and tailor-made service solutions will become increasingly important. We are already well positioned in this respect and, even today, can offer our customers suitable solutions for air conditioning and hydraulics systems flexibly and quickly.

## Customer Services at Liebherr-Transportation Systems

The customer service at Liebherr-Transportation Systems has its own sites in Austria, Germany, France, the UK, Canada, the USA and China. From there, the service employees and engineers provide rail vehicle constructors and operators with the entire range of services for air conditioning and hydraulic systems worldwide: from classic repair in the event of damage to regular maintenance, the provision of spare parts and technical training courses, to the optimization of existing systems. Generally, customers contact the local service managers if required; then, using a centralized tool, customer services coordinates international visits by engineers based, among others, on time slots specified by the operators.

# HVAC Maintenance Contract in Second-Largest Tram Network in France

Liebherr-Transportation Systems maintain heating, ventilation and air conditioning (HVAC) systems fitted to 85 Citadis trams operated by Keolis in Lyon. The contract, which runs over a number of years, covers different activities as preventive maintenance: identifying leaks in all HVAC systems in the passenger areas. Along with preventive measures, Liebherr's services also include the repair of the HVAC systems, i.e. mechanical and electrical repairs of all kinds and, if necessary, the provision of spare parts for the HVAC units for passenger areas and drivers' cabs. The customer service employees were specially trained for, and authorized by, state-registered institutions for the professional maintenance of the air conditioning systems and in particular the correct handling of the chemicals required. "On the basis of this training, our team is capable of repairing any HVAC system", explains Eléonor Borrallo-Gautier, Head of French Site, Liebherr-Transportation Systems GmbH & Co KG in Paris. "This increasingly includes – as in the case of Citadis trams – systems of third party providers, which in turn reflects the great trust our customers place in Liebherr-Transportation services."

Keolis is a subsidiary of the French state rail transport SNCF and operates the country's second-largest tram network in Lyon, which is the biggest operator of Keolis network. Liebherr-Transportation Systems maintain the HVAC systems of 55 Citadis trams in Saint Priest and the HVAC units of 30 Citadis trams in Meyzieu.

# Air Conditioning Systems Brought to Peak Performance

In one of Liebherr-Transportation Systems' biggest servicing projects Pars nova, a subsidiary of Škoda Transportation, commissioned Liebherr in 2015 not only to repair 63 air conditioning systems in its passenger cars, but also to completely upgrade them. The heating, ventilation and air conditioning systems in the trains, operated on the Hamburg-Prague route, were originally designed to operate at up to 35 °C outside temperature. However the Czech operator requested that the systems should also function reliably at outside temperatures of up to 40 °C and, as part of a major overhaul program, Liebherr customer services are upgrading the systems accordingly. In order to demonstrate the performance of the optimized HVAC systems, a passenger car was tested in Europe's largest rail vehicle test facility in Vienna, where it achieved superb results. The overhaul and optimization of all the systems is set to be completed in fall 2016.


**Liebherr makes 63 air conditioning systems in passenger train compartments ready for hot summers.**

# CFTA Rhônexpress Relies on Liebherr Service

The hot summers in the Lyon region are a particular challenge for air conditioning systems in the trams that are in service there. Robust systems that are not sensitive to high temperature operation are essential, as is professional maintenance. Liebherr was therefore recently awarded the contract firstly to inspect the air conditioning systems in the Stadler Tango trams in Lyon operated by CFTA Rhônexpress, and to develop a solution to ensure the performance and reliability of air conditioning systems made by a third-party supplier - also in case of major outdoor temperature differences. If the test phase during summer 2016 is completed successfully, the passenger areas and drivers' cabs throughout the fleet will be re-equipped accordingly by summer 2017. "We are very proud of this project", says Eléonor Borrallo-Gautier, Head of French Site, Liebherr-Transportation Systems GmbH & Co KG in Paris. "It shows that our customers value the quality of our services and place their trust in us. I am convinced that, with our expertise and technology, we will be able to make a major contribution to improving traveling comfort for the Rhônexpress passengers."


**The Rhônexpress travels every 15 minutes between Lyon city center and the airport.**

# Maintenance, Cleaning and Testing in Montpellier

Liebherr-Transportation Systems has been simultaneously awarded a number of contracts in France relating to the Citadis 401 trams, which the company Transports de Montpellier Méditerranée Métropole (TAM operated by Transdev) uses for local public transport in Montpellier. Thus, a total of 160 heating, ventilation and air conditioning (HVAC) system controls developed and manufactured by Liebherr will be in use in both the passenger areas and the drivers' cabs. The first prototype of the new controls was sent to TAM at the end of 2015.

As part of a further order, Liebherr-Transportation Systems is supplying spare parts to overhaul the HVAC appliances provided by a third-party supplier.

TAM has also commissioned Liebherr-Transportation Systems Customer Services-France , as part of an initial test project, to maintain the air conditioning systems of another manufacturer in three passenger area units of the Citadis 401 trams. All components were removed and cleaned, and replacement parts were installed. Subsequently, the operating function was tested. The planned objectives were to improve the functionality and simplify the future maintenance of the HVAC systems. After the successful acceptance, TAM placed an order with Liebherr for the pre-series maintenance of four more trams. As part of these orders, Liebherr-Transportation Systems prepared the technical maintenance instructions for the Citadis 401 trams.

In addition, in spring 2016, Liebherr was awarded the contract for cleaning the air ductwork of all the Citadis 401 trams. The aim was to improve air quality and hygiene in the carriages. In June 2016, the order for cleaning the ducts of 27 trams in the successor model, the Citadis 302 followed.

# People and Opportunities

## Scrum: Step by Step as a Team Towards Project Success

**Some development projects are too large and complex for every minor aspect to be detailed in a classic requirements and functional specification for all concerned right at the start of the project. These projects therefore always represent a particular challenge for the project team in question. Liebherr-Transportation Systems decided to introduce a different working method for its product and project management. The company has given its employees the chance to learn the Scrum method.**

Scrum works differently from classic project management. This is already clear from the name, which comes from the world of rugby football. Scrum is agile and iterative. With this management method, the company sets an objective, but the team itself sets out how it will achieve it. The project and the related planning are continuously moved forward on an iterative basis. From the very beginning, representatives of all the necessary departments are involved and all contribute to the solution. At Liebherr-Transportation Systems, the members of the Scrum team come from divisions that include Project Management, Engineering, Simulation and Quality Assurance. “Our team is interdisciplinary, not hierarchical, and makes its own decisions. This releases a great deal of motivation and creativity if one is prepared to change one's way of thinking”, explains Lejla Halilovic, team leader from the Project Management

Department of Liebherr-Transportation Systems GmbH & Co KG in Korneuburg (Austria).

Initially, the ten-person team practiced the new way of thinking and working for a week with an external Scrum coach. Liebherr then created the necessary framework conditions to enable the team to implement the Scrum process in its everyday work. This includes, for example, all members taking part actively in the daily meetings. In the short discussions, the team members sort out the tasks between them, transparently and flexibly. This is one of the few but clearly defined rules of Scrum. “Because we come from all sorts of different disciplines, we can constantly exchange and expand our knowledge and experience and thus move the project forward on schedule. This is an advantage for everyone involved, including our customers, of course”, says Head Technician Walter Rezania.

The management method is also characterized by the short working intervals. Each task must be broken down by the team members into units that are small enough to be dealt with in a three-week cycle, known as the Sprint. For Michael Canori, Senior Engineer, the central task here is “not to persist in the Sprint endlessly, but to pursue the objective, even though not every detail has been planned.” Igor Cvijetinovic from the Purchasing Division, and Andreas Griletz, Production Planning, see the main advantage as being the interdepartmental cooperation and thus the “transparency of every Scrum member.” Another effect of the interdisciplinary team: “Because of the mutual support provided, projects are characterized by a strong team spirit, rather than departmental thinking”, is how Quality Assurance officer Harald Schambeck sums up the approach.

**The interdisciplinary team – a few team members are shown here – works with the Scrum method on a new product development.**

# “Anyone Who Wants to Train Further Will be Given Plenty of Support”

**Stefan Hummel is 28 years old, studies Business Administration and Engineering at the Technical University of Applied Sciences in Vienna, where he is researching “Customer Service 4.0” solutions as part of his Master’s thesis – and works for Liebherr-Transportation Systems in Korneuburg at the same time.**

**Mr. Hummel, when did you start working for Liebherr, and what has been the biggest project for you so far?**
I started working for Liebherr in May 2011 as a Technical Advisor in Customer Services Materials Handling after completion of my engineering training at Hollabrunn Higher Technical College. In the same year, shortly after I had started at Liebherr, a new version of the Enterprise Resource Planning (ERP) system was to be implemented in Korneuburg and all our service locations worldwide. This integrated application can be used, for example, to plan the need for capital, labor, material and even consumables comprehensively and company-wide. A fascinating concept! So I was given the opportunity, only shortly after my arrival, to be responsible as a key user for the launch of the system in customer services. The project ran from 2012 until its implementation at all locations in 2014, which required a considerable amount of coordination. However, I had all the flexibility and support I needed here and I am still responsible for all questions arising in regard of the system in the Customer Service division. My second major project is undoubtedly my Master’s thesis.

**Your Master’s thesis is directly related to your own field of activity. How much of an asset is this?**
In my Master’s thesis, I am looking at new options for services in the context of innovative Industry 4.0 approaches. This is an important subject for Liebherr-Transportation Systems, which is why my thesis is very practically based. Everything I research as part of my thesis directly flows into my area of activity at Liebherr – and vice versa. Thus, it’s a win-win situation.

**Why did you start this course of study and how is it compatible with a career?**
Liebherr is an international technology company, but it has a family feel. Anyone who announces a desire to train further, or to work in exciting projects which are often internationally based, is given plenty of support. Liebherr supported me during my studies, partly thanks to its flexible working time models. After three years, in the middle of 2014, I completed my part-time Bachelor’s degree in Business Administration and Engineering at the Technical University of Applied Sciences in Vienna, and started my Master’s in the same subject straight after. The lectures take place in the evenings or on Saturdays, therefore outside normal working hours. For my semester abroad, in Sweden, I was able to make use of a part-time education opportunity, so that I could return to full-time work just after the semester without any problems. I also worked part-time during the key phase as I was writing my Bachelor’s thesis. Many of my fellow-students working in other companies were not offered this kind of arrangement. Certainly, I had the advantage of being able to keep my head clear for studying whilst continuing my career progression with Liebherr.

**Where do you go from here?**
Looking into the future, I still see myself in the area of industrial servicing. I wouldn’t have thought this just two years ago, but it is a subject that is set to increase in importance in the future, and one that I am very much interested in. From the beginning, working in the company has offered me plenty of responsibility and personal customer contact. This is what makes it so exciting!

Stefan Hummel (right) with Wolfgang Böttcher, Head of Customer Services


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# Liebherr-Aerospace

## A Major Milestone for Liebherr: Orders for the Boeing 777X

**The Boeing 777X will be the world's largest aircraft with two engines. Its eye-catching features include the wing tips, which are folded upward after landing by means of a powerful folding wing tip actuation system. Liebherr-Aerospace was selected by Boeing, the US aircraft manufacturer, to develop the fold subsystem. The technical solution is a world first in commercial aviation.**

**First folding wing tip actuation system in civil aviation**

The new aircraft program from Boeing Commercial Airplanes, the 777X, is to be much more fuel-efficient than the current generation of aircraft. To achieve this goal, Boeing has opted for a longer wing design with a span of 71.8 meters. The aerodynamics of the wing combined with new energy-saving engines will considerably reduce kerosene consumption and will help airline companies not only to save fuel but also to reduce other costs such as airport charges. The folding wing tips reduce the wingspan from 71.8 m to 64.8 m on each side, allowing the 777X to use standard gates at the airports, like all other aircraft, without any additional costs for the airline. Before the aircraft takes off, the wing tips are once again folded out into the horizontal position.

The components for folding wing tip actuation system for the 777X will be supplied by Liebherr-Aerospace Lindenberg GmbH, Liebherr's competence center for flight controls and landing gear systems. In December 2014, Boeing Commercial Airplanes selected the company to supply the fold subsystem, the latch pin actuator and the secondary lock actuator. The contract to develop and manufacture these components and to service them throughout their life cycle is a great success for Liebherr-Aerospace.

**Follow-on contracts for the 777X**

During the development phase for the first prototypes for the fold subsystem, Liebherr-Aerospace was able to announce another success, when Boeing awarded the next

contract for the 777X: Liebherr-Aerospace will also be supplying and servicing the power drive unit and the hydraulic motor for the leading edge actuation system.

And in addition: because of the company's extensive experience in high-lift systems and especially in geared rotary actuators for long-range commercial aircraft, Liebherr-Aerospace will not only design, manufacture and service the leading edge actuators, but also produce the trailing edge actuators. These actuators are among the largest ever installed in a passenger aircraft. Boeing is responsible for their design and development. The aircraft manufacturer is supported in this by Liebherr-Aerospace from its office in Seattle, Washington (USA), and its facility in Lindenberg (Germany).

Boeing also decided to award the contract to Liebherr-Aerospace for the construction of an iron wing test rig for the 777X's high-lift system and mini test rigs for secondary flight controls. These test rigs will be built at the company's test center for flight controls in Lindenberg. The iron wing test rig will be installed there, whereas the mini rigs will be delivered to Boeing's site in Everett, Washington (USA).

**First milestone reached**

Work is proceeding apace in order to deliver all the components on time to the highest quality standards. "Liebherr-Aerospace has been developing and manufacturing actuators for various aircraft types for more than four decades. We know how these systems work, and make use of all our experience to create innovative developments such as the Folding Wing Tip actuation system", explains Wolfgang Süß, Program Manager Folding Wing Tip System at Liebherr-Aerospace Lindenberg GmbH. "We build prototypes at a very early stage and subject these to extensive tests. In this way, we can ensure that our systems work perfectly when they are produced in series."

On its way to producing the powerful folding wing tip actuation system for the 777X, Liebherr-Aerospace reached the first milestone in March this year: The first proof-of-concept prototypes were delivered to Boeing on time. This illustrates the substantial progress that has been jointly accomplished by Boeing's and Liebherr's engineering team in the design and development. The parts will be used on a prototype test rig at Boeing, with testing planned to begin mid-year.

The preparation works for the iron wing test rig and the test rig for the power drive unit of the high-lift system are also proceeding according to plan: Liebherr-Aerospace is expanding the capacities of its test center in Lindenberg and the intention is that the new, planned 1,440 $m^2$ test building will be completed and ready to move in this summer.

© Boeing

# Rolls-Royce and Liebherr-Aerospace: Joint Venture for Power Gearbox

**An integral part of the new UltraFan™ engine design is the power gearbox. It enables the engine to deliver a power equivalent to the horsepower of 500 family cars. In order to develop manufacturing capability and capacity for the power gearbox, Rolls-Royce and Liebherr-Aerospace are combining their innovative strength and expertise in a joint venture.**

Aerospace Transmission Technologies

UltraFan™ is the name of Rolls-Royce's impressive engine of the future. With its market launch planned for 2025, it will combine outstanding performance and consumption in a way that has never been seen before in the aviation world. The renowned British engine manufacturer is aiming with the UltraFan™ to lower fuel consumption by 25 percent compared with the first generation of its Trent engines. This will provide considerable savings on operating costs for airlines. Other advantages will include reduced $NO_x$ emissions and a far smaller noise footprint.

In order to develop manufacturing technologies for the power gear drive train components, Rolls-Royce and Liebherr-Aerospace founded the 50:50 joint venture “Aerospace Transmission Technologies GmbH” based in Friedrichshafen on Lake Constance (Germany). It is co-led by two Managing Directors, Heike Liebe from Liebherr-Aerospace and Dr. Rob Harvey from Rolls-Royce.

**A perfect combination of expertise**

The areas of expertise of the two joint venture partners complement each other perfectly. Rolls-Royce, one of the world's leading manufacturers of engines, is very experienced in the use of reduction power gearboxes and has used them in

**Liebherr brings a wide range of expertise and high-precision manufacturing skills to the joint venture.**

**Successful collaboration: Employees at Aerospace Transmission Technologies GmbH and their Managing Directors Dr. Rob Harvey and Heike Liebe (front row, third and second from right)**

thousands of engines. The British corporation is therefore leading the design definition and design integration of the power gearbox, as well as the testing activities.

Liebherr brings to the joint venture its unmatched production engineering expertise. This includes the know-how held by Liebherr-Aerospace Lindenberg GmbH, whose plant in Friedrichshafen is the competence center for the high-precision manufacture of gear components. Specialist knowledge is also being contributed by Liebherr-Components Biberach GmbH. Its site in Biberach an der Riss (Germany) develops and produces planetary gears and other components for cranes, earth-moving machines, dockyard and deck cranes made by Liebherr as well as for wind power plants. Each year, the factory supplies 36,000 gears and cable winches alone. In addition, the joint venture will profit from the experience of Liebherr-Verzahntechnik GmbH in Kempten (Germany), where gear cutting machines and tools for the manufacture of gear systems have been developed and produced for decades. This special combination of expertise in aviation, gear production and machine tools is enabling Liebherr to focus its production technology most effectively on the new power gearbox.

**Sophisticated refinement**

The partners are facing a few years of work yet until the power gearbox takes its first flight as part of an UltraFan™ engine, but Liebherr has already supplied Rolls-Royce with an initial gear component for test purposes. The engineers at Aerospace Transmission Technologies GmbH are currently taking over the product planning and the technical documentation from Liebherr. In parallel, Rolls-Royce is building a new test center for power gearboxes at its site in Dahlewitz to the south of Berlin (Germany), which is to be finished later in 2016. With Liebherr-Aerospace's involvement in this exciting new engine demonstrator program, the company is treading on new ground and expanding its field of activity.

# Keeping an Eye on Customers' Needs at All Times

**Brothers Mike and Adam Edwards have been working for Liebherr-Aerospace at its facility in Saline, Michigan (USA) since 2006. They both started as service technicians, before their paths separated – albeit only internally – in 2012.**

**Mike and Adam Edwards, what does your job look like and how did it develop over time?**

Adam: We started our job at Liebherr-Aerospace Saline on the very same day as repair technicians; however, my desire was to work in the machine shop. After a year I began working in the machine shop part-time. As soon as business picked up, I was hired in as a full-time machinist and have been there ever since. My job today primarily consists of working on landing gear components. On a typical day I repair parts that come into the shop by machining off corrosion, replacing bushings, etc. I also manufacture a variety of bushings from stock, and serve as a "backup" when my supervisor is out.

Mike: As Adam mentioned, we both started as repair technicians. I remained in that position almost 6 years, until there was an opening in the Technical Support department. In May 2012, I transferred to the position of Technical Support Analyst. The interesting thing is that a lot of the repairs that are being performed by the machine shop are "out of scope", meaning they are not in the component repair manual. The engineering department then creates repair processes that are as cost-efficient as possible for the customer, for example, by not replacing the damaged parts completely but repairing them if possible. This is one of the duties I have as Technical Support Analyst: to coordinate between our customers - such as for example aircraft operators, airframers, leasing companies - and the engineering department to get these repairs approved.

**Mike (left) and Adam Edwards love aviation and working with Liebherr, a group of companies with a definite family feeling.**

**Who are your customers and what are the biggest challenges in your job?**
Mike: I help support customers working on aircraft fitted with Liebherr-Aerospace equipment in the Americas. I also have the role of Retrofit Coordinator, which can often be a challenge, as there are many operators within the Americas that participate in fleet wide retrofit campaigns. Generally speaking, the objects of our work consist of supporting landing gear, flight control, engine air bleed and air conditioning systems for all major airframes.

By supporting such a wide variety of products for as many customers as we have, there can be many challenges. Every customer has different demands and engineering requirements that we need to follow. Our job is the overall coordination between our station and the customer and to ensure that everything is done correctly. That applies for internal processes as well. Adam and I both serve as certified internal auditors for the AS9110 audit program. By doing so, we audit different departments at Liebherr-Aerospace Saline. We thus make sure that the processes are carried out properly which of course contributes to satisfying our customers.

**Which developments have you seen over the past few years?**
Mike: Over the course of a decade we have seen this company grow tremendously in terms of team members and also facility space. We have both been present for two expansions of the main Liebherr facility and now we are witnessing the building process of a new, separate facility, which will be finished in April 2016. This development is not only good for the economy here, but also for the entire company. Aviation is a very promising industry and I think we're doing great here in Saline.

Adam: As machinists, we are always trying to come up with better procedures by improving and upgrading our processes. This is actually one of Liebherr-Aerospace Saline's quality objectives when it comes to constant development. The company strives to develop new reworking procedures on a regular basis to save time and money for the customer. With that being said, I've seen numerous developments in regards to component reworks.

**What do you value most about being a member of the Liebherr team?**
Adam: A big part of what we value is providing for our families and leading a lifestyle of integrity. That plays into how we work at Liebherr every day. We're always trying to improve, and are doing whatever we can to provide a good product for our customers to help develop the company. That is a huge motivator, and we are just happy to be part of it. This is a great company to work for, and we hope to stay for many years to come!

# New Facility Inaugurated in Saline

In April 2016, Liebherr-Aerospace Saline, Inc. inaugurated its new building at the company's site in Saline, Michigan (USA). With a footprint measuring some 3,000 $m^2$, the plant is located in the direct vicinity of the 13,000 $m^2$ main building. With this new facility, Liebherr-Aerospace will expand its activities in the light manufacturing sector and build abilities to repair heat exchangers.

The plant features the latest and most advanced of manufacturing technologies such as robot-assisted welding as well as 3D non-contact metrology inspections. "The fact that we can now repair heat exchangers on site represents a major improvement to our repair service program in the USA", affirms Charles Thoyer-Rozat, Executive Vice President Customer Support & Services Aerospace of Liebherr-Aerospace & Transportation SAS.

Liebherr-Aerospace Saline, Inc. came into operation in 1991. Today, the company supports customers in the Americas in the fields of inventory, maintenance, repair, overhaul and technical services for air management systems, flight control and actuation systems as well as landing gear systems.

For equipment for which the company has no in-country service capability, it performs a liaison function between the customer and Liebherr's Original Equipment Manufacturers in Europe, Liebherr-Aerospace Toulouse SAS, (Toulouse, France) and Liebherr-Aerospace Lindenberg GmbH (Lindenberg, Germany), including exchanges and repair management.

# The Liebherr Group

**Hans Liebherr established the company that bears his name in 1949. Since then it has grown into a Group of more than 130 companies on all continents, employing almost 42,000 people at the latest count. In 2015 the Liebherr Group achieved a total consolidated turnover of more than 9.2 billion euros.**

The Group's holding company Liebherr-International AG is based in Bulle (Switzerland) and is wholly owned by members of the Liebherr family. The Liebherr Group's corporate culture has been determined from its earliest days by its family ownership. For more than 60 years, Liebherr has demonstrated what this means in terms of stability and trustworthiness, and has striven for a close long-term relationship with its customers and business associates. Liebherr shapes technological progress and aims to retain its position at the leading edge of future technology. All its activities have top



quality as their central element. This principle is upheld by all the Group's employees in their day-to-day work. Liebherr's products are the outcome of its passion and dedication: tailor-made solutions that take the customer's needs and wishes wherever possible as their starting point.

Today, Liebherr is not only among the world's largest manufacturers of construction machinery, but is an acknowledged supplier of technically advanced, user-oriented products and services in many other fields of activity as well. In addition to components and systems in the mechanical, hydraulic and electrical driveline and control areas, they include maritime cargo handling, machine tools and automation systems, aerospace equipment, equipment for the rail industry, domestic appliances and hotels.

**Discover more:**
www.liebherr.com

Domestic Appliances

# Smart Efficiency

This spring, Liebherr-Hausgeräte GmbH introduced its 'BluPerformance' series, a new refrigerator and freezer range that operates with higher energy efficiency. These new appliances further set themselves apart with their premium-quality workmanship, precision touch electronics, and optimized usable net capacity. The new 'BluPerformance' range was revealed to the public for the first time last September, at the IFA 2015 in Berlin. Alongside enhanced efficiency, Liebherr focussed on remote networking capabilities during the development of these models (i.e. 'connectivity', as it is increasingly becoming known). With the new 'SmartDeviceBox', these refrigerators and freezers can easily be integrated via Wi-Fi into smart homes, and therefore be conveniently controlled whilst on the go from a smartphone, tablet and other mobile devices.

Gear Technology

# Bespoke Chamfering

Liebherr's Gear Technology product area supplies the LCD 300 ChamferCut as a stand-alone solution for what is known as the chamfering production process. The ChamferCut principle that the machine uses is now in increasing demand. At the EMO trade fair in 2013 Liebherr introduced for the first time an integrated machine intended for the automotive industry, with gear hobbing and chamfering by the ChamferCut process in parallel during the main machining time. Before long, there were inquiries for a machine devoted solely to the ChamferCut process, which Liebherr satisfied by developing the standalone LCD 300 ChamferCut.

ChamferCut is growing in popularity compared with press-deburring and tapered-end mills, since this process involves the lowest chamfering costs. The special tools are very durable and simple to regrind. Precise, repeat-accuracy chamfers combined with long tool lives speak also for the ChamferCut process. Given the high quality it delivers, the process is particulary popular with car and commercial vehicle manufacturers as well as gearbox and engine manufactures.

Maritime Cranes

# The World's Most Powerful Mobile Harbour Crane

The new LHM 800 can claim a long list of superlatives: eight months' production time, a boom 64 m long weighing 63 t, 18 axles, 144 wheels, a maximum lifting capacity of 308 t and a total weight of 820 t. It sets new standards. From Rostock (Germany), where it was built, Liebherr shipped the first of these cranes at the end of 2015 in fully assembled form to the port of Bronka in St. Petersburg. Situated on the south shore of the Gulf of Finland, this seaport is becoming an increasingly important freight handling location on Baltic shipping routes. To enable larger ships and heavier industrial goods to be handled, the authorities there decided to order the largest current model in Liebherr's mobile harbour crane programme.

Compared with the LHM 600, previously the most powerful Liebherr mobile harbour crane, the LHM 800 can handle approximately 100 t more. It is also prepared for use with the Liebherr-Sycratronic® tandem lift system: a single operator can control two of these cranes simultaneously.

Hotels

# Latest Hotel News

The Liebherr Group owns six hotels in Germany, Austria and Ireland. The four-star superior Löwen Hotel Montafon (www.loewen-hotel.com) in Schruns (Austria) has been completely renovated. Generous use of wood and warm colours create an agreeable ambience (picture on left). Rooms furnished to the most modern standards and the new lounge are sure to meet the approval of every guest.

The Interalpen-Hotel Tyrol (www.interalpen.com) in Telfs (Austria) has a firm place among the 'Leading Hotels of the World'. The 'Hofburg' was opened in 2014 (picture below). This new event location in the hotel is chic, stylish and exclusive.

**The 'Hofburg' in the Interalpen-Hotel Tyrol**

**Completely renovated: the Löwen Hotel Montafon**

Tower Cranes

# Liebherr Crane Is Germany's Highest Point

Freezing temperatures, snow and winds of up to 280 km an hour: the Liebherr 150 EC-B 6 Litronic Flat-Top crane has to withstand some very tough conditions at the top of the Zugspitze, Germany's highest mountain. This tower crane is being used on the construction of the new Eibsee cable car line. With a working radius of 50 m, a height of 18.6 m under the hook and a maximum load capacity of 6,000 kg, the crane has been especially configured for severe weather conditions and is therefore ideal for this project in the Bavarian Alps. The 150 EC-B, incidentally, is 13 m higher than the peak of the Zugspitze – making this crane, for a few years at least, the highest point in Germany.

Last July the crane was dismantled and moved by the Heliswiss helicopter company from the midway station at Sonnalpin to the top of the mountain, where a team of experts from Liebherr assembled it, again with the aid of a helicopter. The challenge of working on such a difficult site called for perfect teamwork between the Liebherr mechanics, the helicopter pilot and the staff of the Zugspitze railway, but thanks to detailed preparation and the pilot's and mechanics' skill the whole operation was completed professionally and no problems were encountered.

Starting in 2018, the new Eibsee cable cars will carry visitors from the Sonnalpin station at the halfway mark to the top of the Zugspitze. The supporting pylon, at 127 m, is the highest in the world. Another record figure is the 3,207 m span between the support pylon and the upper station, unmatched by any other cable car line in the world.

Mining

# Liebherr's First Mining Crawler Tractor

The Liebherr PR 776 will debut at the 2016 Bauma – the world's first crawler tractor in the 70-ton class with continuously variable hydrostatic transmission. The Liebherr 12-cylinder diesel engine gives a peak output of 565 kW (768 hp), with power for the toughest mining and material recovery operations; however, fuel consumption is markedly lower than the industrial performance standard for the equivalent thrust value. This modern continuously variable hydrostatic drive concept – as used on all Liebherr crawler tractors – is new in this service-weight category, making the PR 776 exceptionally economical to operate.

Components

# All-Round Awareness Means Greater Safety

On the construction site, on the farm or on the road: day-to-day work can mean exposure to various risks. In particular, interaction between human beings and machines calls for a high degree of concentration on the part of machine operators and everyone else working nearby. Liebherr, therefore, develops work assistance systems that avoid these critical situations and make the work easier, as well as enhancing safety, reducing costs and boosting productivity.

A current development project in this area is an environment recognition system from Liebherr-Elektronik GmbH. Strongly built, dirt-resistant cameras, a computing unit with ample capacity and a high-resolution display help the driver avoid accidents. This is how the system works: Digital image processing identifies people and objects within a defined detection area. Obstacles are outlined on the monitor screen, with a clear indication of their distance from the machine. As the distance grows smaller, the outline on the screen changes, using the familiar green, yellow and and red traffic light colors. This enables the driver to react rapidly before the situation becomes acutely dangerous and violent contact or severe injury could occur. The system enhances operating safety and helps prevent possible accident damage. By assisting the driver in this way, he or she can concentrate fully on the task in hand.


**Distance to the obstacle is outlined on the monitor screen**

The assistance system permits various camera positions to be adopted. Instead of a combined camera, two single cameras can be located individually. Thanks to this flexible installation, the potential detection area can be optimized according to the application of the customer. The combination with the adaptable algorithm makes the system highly versatile. Liebherr is developing its assistance system not only for new mobile machines but also for retrofitting to existing ones.

LIEBHERR

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