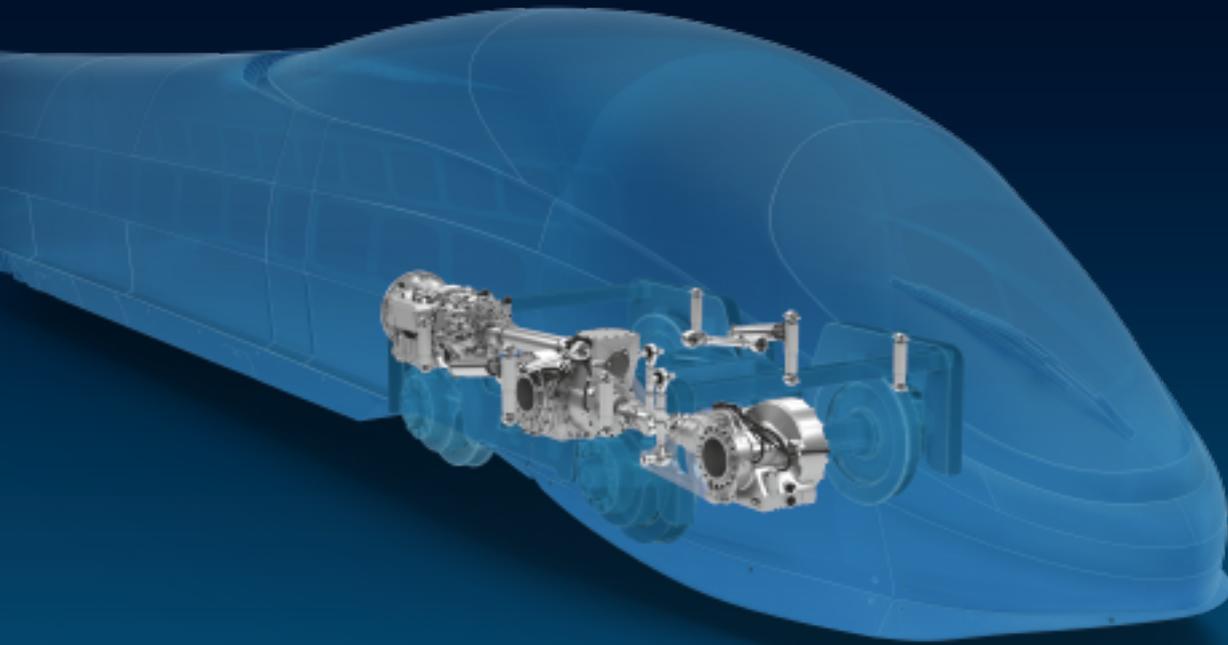




# Worldwide on track

ZF technology for rail vehicles





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**Worldwide on Track.**

Its enthusiasm for innovative products and the uncompromising pursuit of quality have made ZF a global leader in driveline and chassis technology, as well as active and passive safety technology. ZF also makes a sustainable contribution to shaping the future with its “off-road” applications. Thanks to the company’s over 90-year tradition in the rail business, manufacturers and operators of rail vehicles know ZF as a supplier of flawless, reliable, and long-lasting products for future-oriented rail travel applications. With the combination of mechanics, electronics and digital technologies ZF offers intelligent connectivity solutions that will further improve productivity and efficiency for long- and short-distance transport.

# Technology that moves.

Sustainable mobility concepts for tomorrow must meet the requirements of modern society with regard to speed, safety, comfort, and sustainability. In railway traffic, this is possible with driveline, chassis and safety technology by ZF.

The world is converging. Urbanization is on the increase. Travellers want to travel longer and longer distances in less and less time. The global flow of goods must be facilitated. In the metropolises and metropolitan regions of the world, millions of people must be transported every day. In our mobile society, rail vehicles compete with airplanes, trucks, buses, or passenger cars in tourist, goods, or short-distance traffic. Their manufacturers and operators are also facing the challenge of offering solutions which fulfill social, environmental, and economic objectives at the same time.

## Into the future on rails

ZF Friedrichshafen AG is a reliable partner for the journey into the future on rails. The company is one of the world's technology leaders in the area of driveline, chassis and safety technology. It offers components and systems



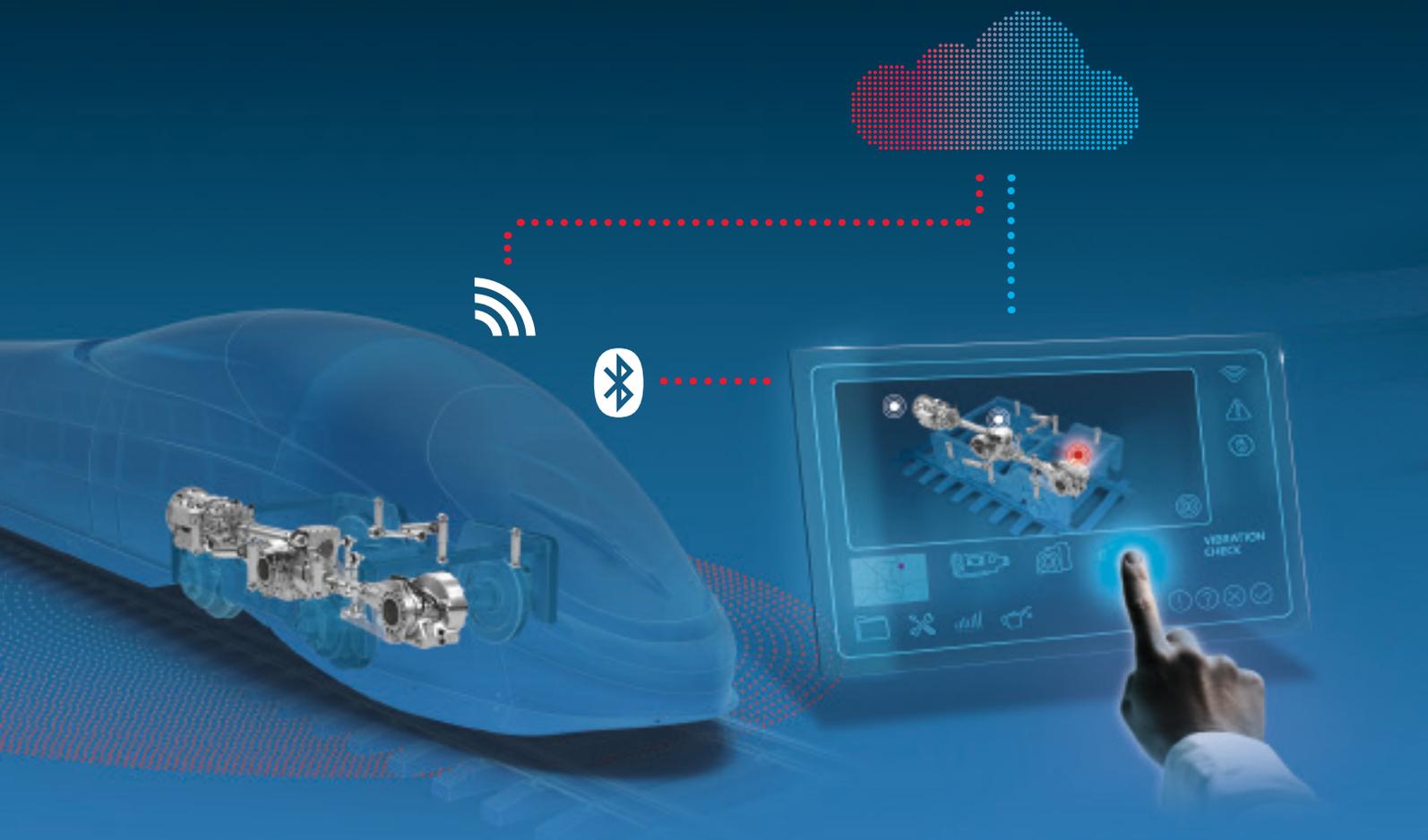


which make railway traffic more powerful without neglecting passenger safety and comfort. By doing so, it significantly contributes for example to the further expansion of the high speed sector where travel speeds of up to 380 km/h are already being implemented in regular operation and in which achieving much higher speeds is an objective. In the growing cities and metropolises around the globe, innovative technology by ZF helps to keep public transport flowing. It makes sure that electric metro city trains and trams also generate a low level of emissions in terms of noise and improve quality of life in the cities in a pleasantly quiet manner. Railway traffic must pay off, both for long-distance and city trains running at short intervals. ZF technologies make efficient mobility possible. Thanks to their functions and their weight-optimized design, the components and systems reduce rail vehicle energy consumption and energy costs. Intelligently designed and robust at the same time, they have low life cycle costs and a long service

life, also under extreme loads and stresses which, for instance, occur in goods traffic and high speed trains. ZF has been active in this field for more than 90 years. In the framework of globally linked processes, ZF develops high-tech products for driveline and chassis applications in cooperation with customers and suppliers. Apart from its experience, ZF also benefits from technical know-how transfer within the Group: If possible, tried and tested commercial vehicle technology is adapted, which makes it possible to reduce development times and apply existing production standards. The results are product concepts impressive in both form and function which optimally adjust to the respective train environment. The components and systems are based on a modular concept. Their modules can be combined based on the performance class and type of the rail vehicles. ZF offers customer-specific driveline and chassis technology which makes rail vehicles ready for the complex requirements of modern mobility.

# Smart mobility.

As a continuous innovator, ZF is preparing for the next generation of driveline, chassis and safety technology with intelligent connectivity solutions that will further improve productivity and efficiency. ZF accepts this challenge and combines mechanics, electronics and digital technologies for rail transport.

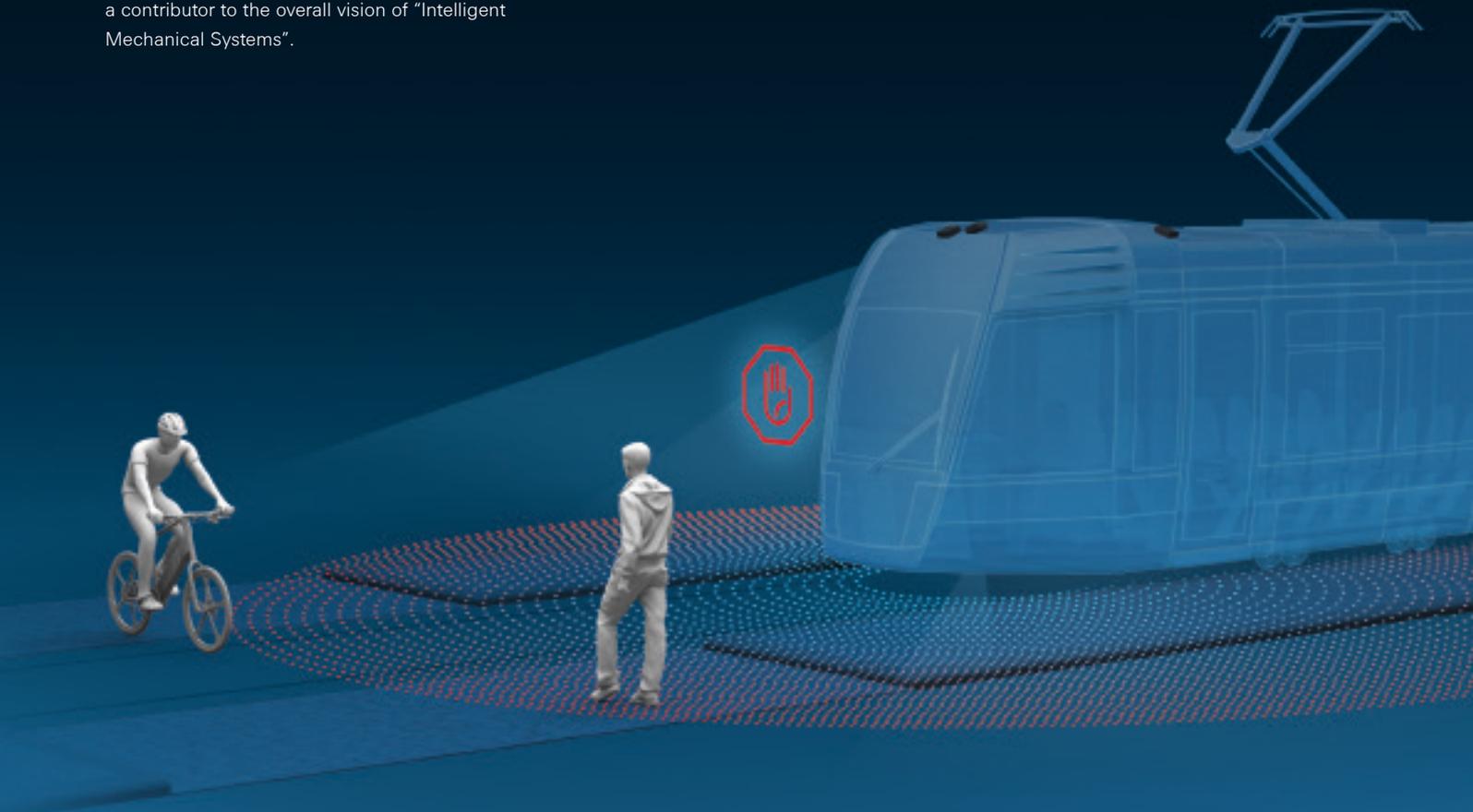


## Smart condition monitoring system connect@rail

Registered by sensors, operational data of the bogie will be transmitted via the internet to the ZF Cloud. Other relevant partners for optimal operation also provide data to determine the best time for maintenance. So unnecessary or costly downtimes are avoided.

### Vision of smart mobility systems

ZF develops a concept of the connected rail as a contributor to the overall vision of "Intelligent Mechanical Systems".



## New technologies

Predictive maintenance planning shortens or prevents shutdown and outage times for rail vehicles. It benefits public transit operators by lowering their operating costs and improving reliability for passengers. The smart condition monitoring system connect@rail demonstrates how integrated sensors and advanced data analysis tools can further improve efficiency, reliability and safety in rail transport. Various sensors record vibrations, oil quality and temperature behavior in transmissions. On top of that, a sensor attached to the unsprung axle drive or bogie measures amplitudes and bumps in the track

system. This enables operators to monitor the status of the tracks and to identify potential hazardous spots early on. With the Smart Typeplate ZF is also simplifying efficient fleet management. The innovative product consists of a chip that ZF has integrated into the typeplate of a transmission. The chip contains the name, material and identification number as well as the technical details. It also records the actual operating hours. This information is stored either locally or decentrally in a cloud. The operator can view this information when the rail vehicle drives into the maintenance depot and record repairs recently carried out. This makes it easier to see which trains actually require maintenance.

# Efficient and groundbreaking.

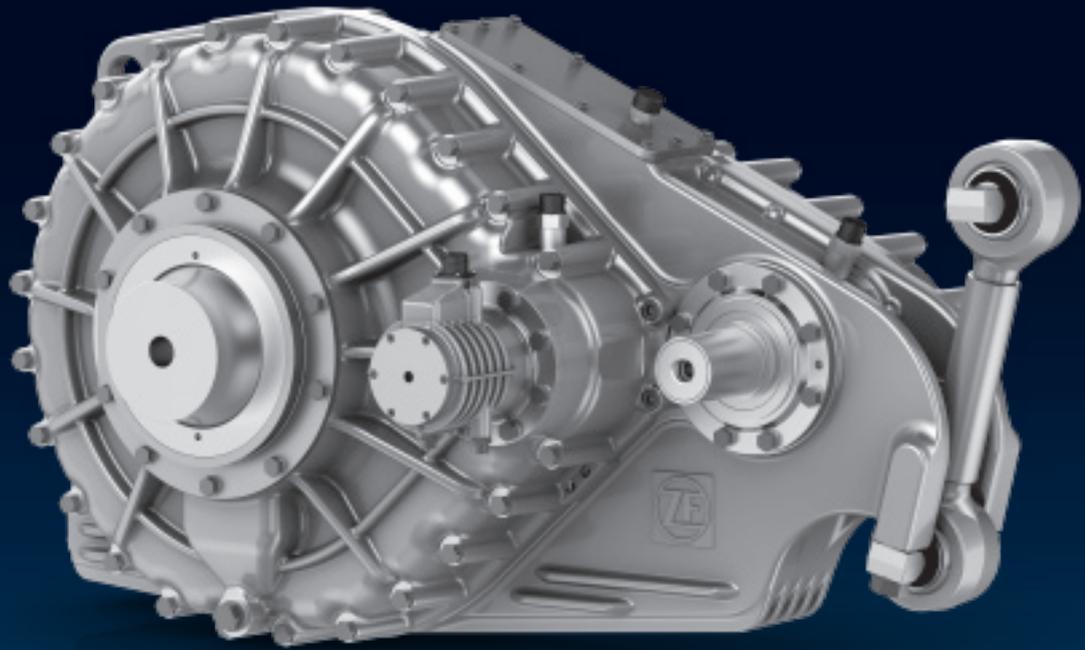
The Get2 rail drive concept – More gears for less energy consumption. With the world's first multispeed transmission for Electrical Multiple Units (EMUs), ZF reacts to increasing energy costs.

Efficiency is the essential term when it comes to progress in technology. Innovations must pay off for manufacturers, operators, and customers. From an environmental and social perspective, we must also conserve resources, energy, and raw materials, all of which are becoming increasingly scarce. In ZF's international network of development centers, approximately 7100 engineers are working on the mobility of tomorrow. With success, because innovative products by ZF keep setting standards for state-of-the-art technology.

One example for this is the Get2 rail drive concept. With electricity prices on the increase, maximum efficiency is also becoming more important for Electric Multiple Units. Anticipating this development, ZF therefore developed Get2. As opposed to conventional EMU transmissions, this innovative transmission concept has two gears thanks to an additional starting gear. The multispeed transmission continuously moves the load point in such a way that the electric motor and converter always work in a favorable efficiency range. This saves energy and provides greater tractive power at the same level of drive power. These advantages

can be brought to bear particularly during the starting processes and thus for metro applications, since the distances between metro stops are short. In this application, Get2 generates energy savings of up to five percent compared to one of the most advanced current metro drive systems.

During constant travel, Get2 also reduces energy consumption because it has a neutral position in addition to the two gears. If this is activated, the rail vehicle is in coasting mode, meaning that all drives are decoupled in order to avoid losses. During deceleration, the multispeed concept makes it possible to use the respectively optimal recuperation point of the traction machine, which improves energy recuperation. ZF's multiple traction system also maintains the same high level of passenger comfort in spite of the gear changes: The intelligent electronic control system engages all drive units in the vehicle automatically in serial sequence and thus prevents noticeable interruptions of tractive force. The gears are changed extremely fast. The train accelerates smoothly.



**-5%\***

### Energy savings

Get2 offers maximum efficiency as well as comfort, reliability, and durability. Metro applications offer the highest energy saving potential.

\* compared to one of the most advanced current metro drive systems



Learn more about the ZF Get2 concept. Watch the video on your smartphone.



# Powerful and cost-effective.

Innovative ZF drive systems for Diesel Multiple Units benefit from transmission technology which has been tried and tested millions of times in road traffic. They offer increased ride comfort and safety with reduced fuel consumption.

## ZF EcoLife Rail

As a technological leader for modern driveline technology, ZF guarantees tangible customer value. Noticeable fuel savings, a longer service life, and optimum shift comfort – those are the advantages of the currently most powerful powershift transmission on the rail vehicle driveline technology market: ZF EcoLife Rail. It was developed based on the ZF EcoLife bus transmission and adapted for railway traffic. The transmission is custom-tailored for Diesel Multiple Units with an engine output torque of up to 2500 Newtonmeter. The torque converter ensures smooth starting processes and optimal acceleration values. The six mechanical gears keep the engine in an economical speed range. The integrated retarder considerably reduces wear in the mechanical brake system. System safety is ensured by the “Failsafe Principle”.

## ZF EcoWorld

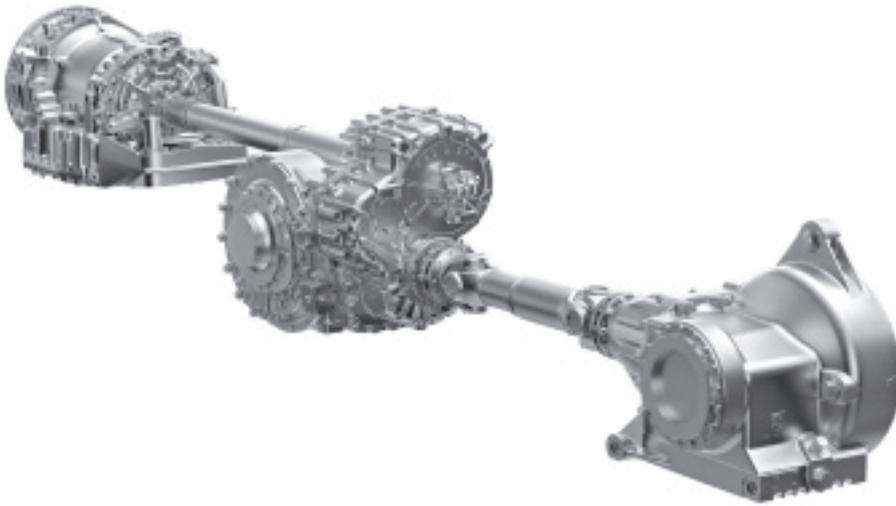
ZF’s most recent development, ZF EcoWorld, has six speeds, an integrated reversing function and hydraulics as well as reduced interfaces to enable retrofit to existing vehicles and thus reduce costs. It enables an unrestricted towing and coasting function which can save an additional five percent in fuel depending on the route, engine type and load condition. The transmission achieves maximum efficiency and is equipped with a powerful torque converter. This significantly improves travel comfort for passengers. In addition, the transmission is prepared for various optional condition monitoring functions.

## For a variety of applications

Axle drives in modular design are available for the ZF powershift transmissions. These are adapted to the respective performance class. The bevel gear transmissions (slave) and gearset reversing transmissions (master) are available in different ratios for bogies with one or two driven axles. Axle loads can be up to 22 tons. The Rail Drive Control System (RDCS) automatically controls and monitors the shift reversal process. The RDCS which is integrated in the Train Control Unit ensures optimal integration of the ZF drive system into the train environment and is also the central communication interface with the main train computer.

A newly developed wheelset gearbox completes ZF’s drive solution around EcoWorld. The new drive system can be combined with a range of axle ratios. This makes it suitable for slow speed operations as well as for fast rail vehicles in long-distance transport. At higher ratios, EcoWorld also handles steep gradient routes without difficulty.

## ZF drive systems for DMU's are characterized by reliability and cost-effectiveness.



### Rail Drive Control System (RDCS)

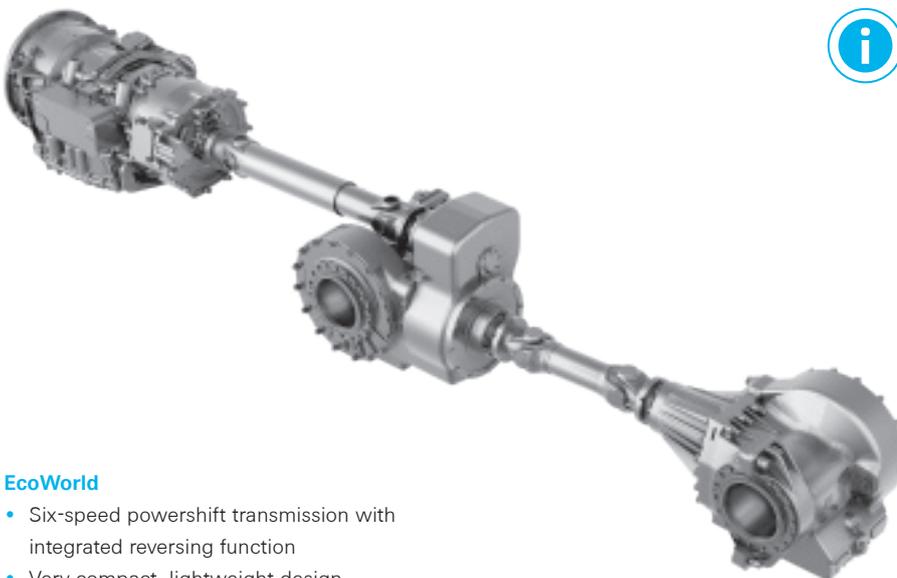
- Automatic control of the entire shift reversal process
- Stable electrical integration of the ZF components in the train environment
- Reduces integration efforts
- In the overall system, it fulfills the EMC requirements according to EN 50121

### EcoLife Rail

- Fuel savings of up to 20 percent compared to hydrodynamic transmissions
- Significant reduction of life cycle costs
- Compact installation space
- High performance density
- Integrated electronics
- Optimum power-to-weight ratio

### Gearset reversing transmission

- Mature system
- Tried and tested, standardized components
- Completely integrated shift unit
- High flexibility in terms of ratio and axle load



### Optional condition monitoring:

Smart Typeplate, oil level sensor, oil condition sensor, acceleration sensor, bearing temperature monitoring

### EcoWorld

- Six-speed powershift transmission with integrated reversing function
- Very compact, lightweight design
- Enables unrestricted towing and coasting function

### Wheelset gearbox

- Master and slave unit with hypoid gearing
- Optimal vehicle configuration thanks to numerous ratio options
- Robust and tested components for utmost reliability



# ZF Repowering. Retrofitting for in- creased profitability.

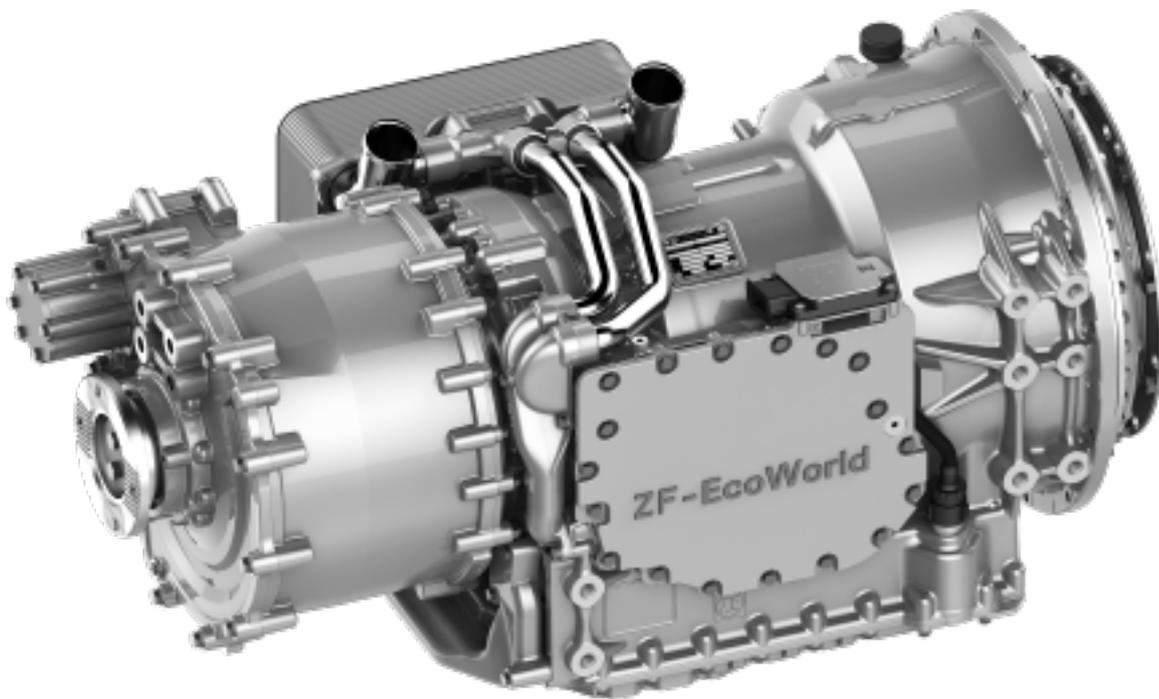
Replacing the driveline with ZF driveline technology pays off: The EcoWorld with its integrated reversing function reduces the fuel consumption of Diesel Multiple Units in public transport and regional traffic by up to 20 percent.

If public transport and regional traffic train operators want to stay on the right track for success, their vehicles must run cost-effectively for as long as possible. With fuel prices on the increase, this is becoming a challenge. For Diesel Multiple Units, fuel costs alone make up two thirds of the vehicles' total life cycle costs. ZF's Repowering solutions aim at reducing fuel consumption and thus life cycle costs and at extending the service life of the rail vehicles. In the repowering process, outdated driveline technology is replaced by modern, efficiently working driveline components. In this case, the ZF EcoWorld replaces a hydrodynamic transmission in the DMU.

# 20%

## Fuel savings

Confirmed in field tests:  
The ZF Repowering solution achieves  
average fuel savings of up to 20%



## Repowering benefits operators and the environment

The ZF EcoWorld, especially developed for the railway market, clearly increases the customer benefit in comparison to his successful predecessors. The torque converter perfects the startup process and provides optimal acceleration values. The gear changes occur without tractive force interruption. The transmission which, compared to hydrodynamic competitor transmissions, weighs considerably less, has six fine-tuned mechanical gears. They keep the engine in an economical speed range. Fuel consumption and operating costs are reduced. In combination with axle drive variants with or without reverse transmission, repowering rail vehicles with EcoWorld can generate up to 20 percent of fuel savings. This is a convincing result, both economically and ecologically.



### ZF EcoWorld

- Significant reduction of life cycle costs
- Acquisition costs are amortized within 2 to 3 years
- The oil quantity is cut in half to 48 liters
- The high ride comfort remains unchanged
- Environmentally friendly
- Improved driving dynamics

# Versatility in railway traffic.

Electric Multiple Units circulate between cities, connect the city to the countryside, take commuters from the suburbs to the city and back. This application versatility must be mirrored by the flexibility of the technology. Based on tried and tested drive concepts, ZF develops customer-specific solutions.



Whether in regional trains or city trains, Electric Multiple Units (EMUs) differ depending on application, route, and capacity requirements. The drive concepts must thus be accordingly adaptable. Bevel gear transmissions and spur gear drives by ZF can be designed based on the respective customer requirements. They are, for example, available with one or two stages, full or partial suspension, in different ratio variants, and with aluminum or spheroidal cast iron housings. Their design can also be adapted to fit vehicle-specific spatial conditions.

Given their high degree of efficiency, the drive systems which have been tried and tested under everyday conditions thousands of times support the implementation of efficient and environmentally friendly mobility. They run smoothly, which increases passenger comfort, and ground spiral bevel gears and helical spur gears reduce noise emissions. Thanks to their special gearing design and latest labyrinth technology, the transmissions also operate very well under extreme weather conditions of up to -40 °C. The transmissions are designed to be easy to assemble and easy to service, which results in low life cycle costs.



## EMU – Highlights at a glance

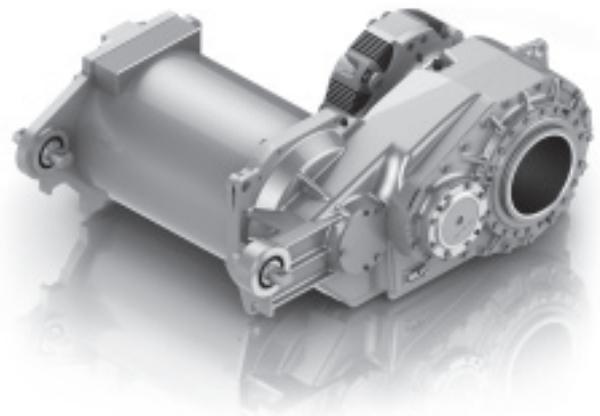
- Low noise development thanks to ZF gear technology
- Competence for customer-specific solutions
- Long service life
- Optimum efficiency
- High design flexibility
- Compact design
- Suitable for extreme climatic conditions



**Flexible technology for customer-specific solutions.**



Axle-mounted, two-stage spur gear drive with partial suspension



Flexible, axle-mounted drive, two-stage spur gear drive with a wedge packet coupling



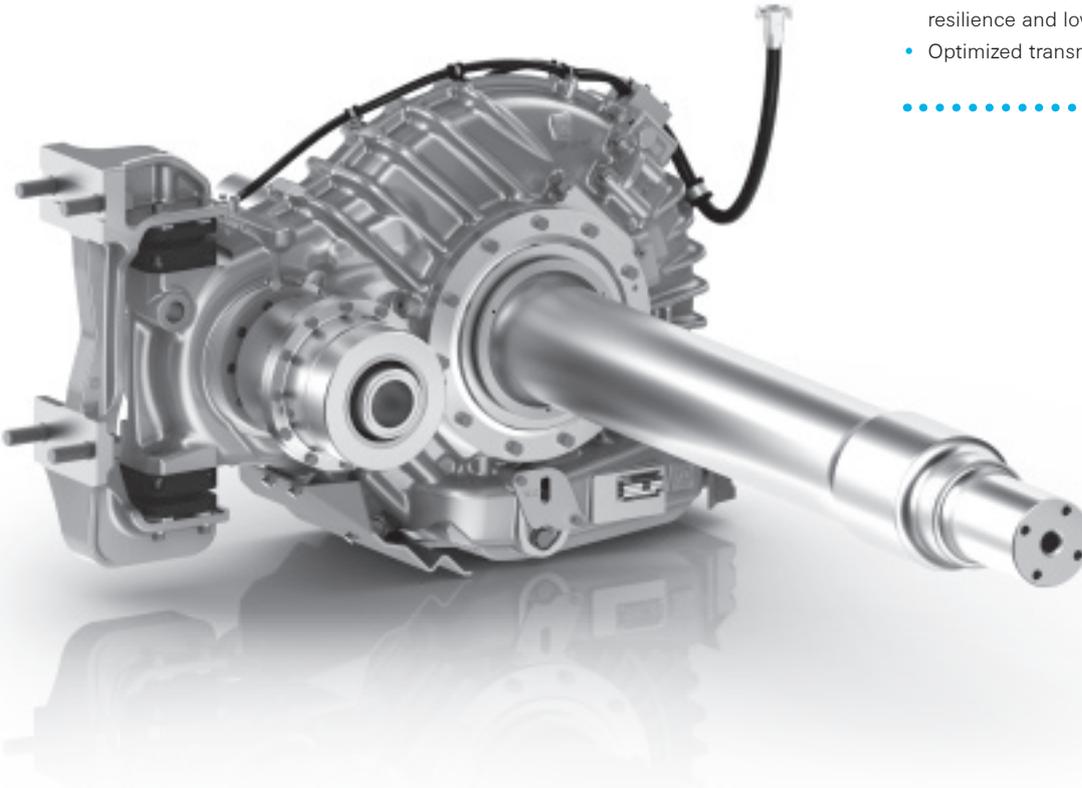
# With high speed into the future.

When traveling feels like flying. The trendsetting ZF Highspeed transmission which can be flexibly adapted to customer requirements can help achieve maximum speeds from 250 up to 600 km/h on rails.

The world is moving and people move with it with increasing speed. In the high speed sector, train drives must be powerful and highly resilient. Just like ZF Highspeed transmissions. With this product which is perfectly adapted for application in high speed trains, the technological leader ZF establishes a new benchmark. The single-stage transmission which has been used in volume production for years, makes it possible to achieve travel speeds of currently up to 380 km/h. And what is more: The ZF Highspeed transmission is already designed to equip future train generations. It is based on a modular design, which makes it possible to implement transmission variants for maximum speeds of up to 600 km/h.

Thanks to the transmission's modular design, it can be used with extreme flexibility. Different center distances and ratios can be achieved with one housing, which means that train operators can cover vehicles of different performance classes with only one transmission type. Both the adaption of the transmission to special customer requirements and its installation into the vehicle have been made easier. Prototypes can also be made available quickly.

# ZF Highspeed. A transmission type for all performance classes.



.....  
**High speed system**

- Different bearing designs
    - Standard solutions
    - Bearings with special coating
  - One housing for different ratios
  - Optimized oil supply
  - New, improved labyrinth technology
  - Gear technology with increased resilience and low-noise design
  - Optimized transmission weight
- .....

## A resilient drive system

At travel speeds of more than 250 km/h, the materials are under extremely high stress. The ZF Highspeed transmission is designed for this. Thanks to modern production technologies, the components of the high speed transmission, for instance the ground bevel gearsets made from high-strength ZF 1 A case-hardening steel, are so resilient to high loads and stresses that the prescribed maintenance cycles can be easily implemented. In addition, the precise gear technology ensures extremely low-noise operation. With its product concepts, ZF actively promotes a new quality of traveling.



.....  
**Bevel gearset**

- Low noise development
  - Robust design
  - High performance
  - Customer-specific design is possible
- .....



# Urban efficiency.

Metros reliably carry huge numbers of people around the world's metropolises every day with minimal emissions and independently of road traffic. ZF technology makes this mode of transport even more cost-effective.

Megacities and conurbations are unimaginable without the means of mass transportation, the metro. In public passenger transport, efficiency plays an essential role. This is why ZF offers driveline technology which provides added value to the operators.

## The perfect choice

ZF puts its many years of experience in rail vehicle drives into practice with the new, modular metro gearbox and simultaneously sets a new benchmark. This modular product was created for vehicle manufacturers that want to achieve great performance while providing robust and economic vehicles. The new gearbox family for metro applications operates up to a maximum speed of 100 km/h. Gearbox models are available for variable center distances and with variable gearbox ratios. High-quality, standardized components mean that the product can be supplied quickly at an excellent price.

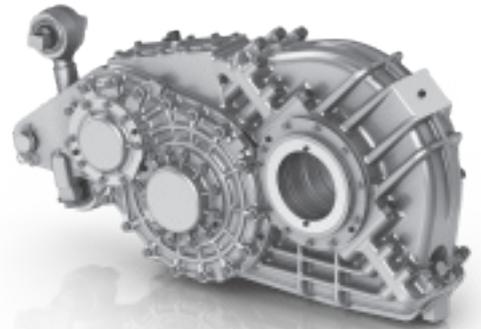
## One innovation, many advantages

The single-stage ZF metro gearboxes with thrust collar technology are optimally designed for little service effort, low life cycle costs, and a long product service life. These are advantages based on a special technical feature: While in conventional helical-toothed metro gearbox axial forces put stress on the bearings and reduce efficiency, two innovative tapered thrust washers prevent this effect. They are mounted to the left and right of the drive pinion, slide on an oil film on the output gear, and thus absorb the axial forces. This makes it possible to use cylindrical roller bearings for input and output shafts. These need not be adjusted and considerably minimize assembly effort and maintenance requirements. The operating temperature of the bearings is only 2 °C above the oil pan temperature, which reduces stress on the bearings and contributes to increasing product service life. Efficiency is a factor for the metro in Los Angeles. Several hundred railcars are equipped with an innovative lightweight ZF gearbox. Thanks to its aluminum housing, it is 15 percent lighter than the products which are currently available on the North-American market. Volume production of the product tailored to fulfill the local requirements is carried out in the US.

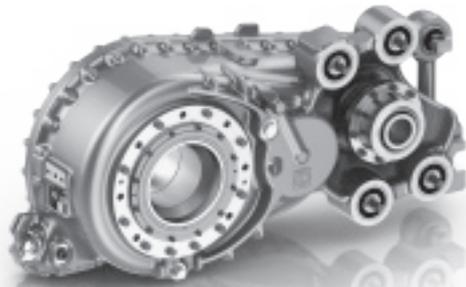
Reliable and service-friendly technology.



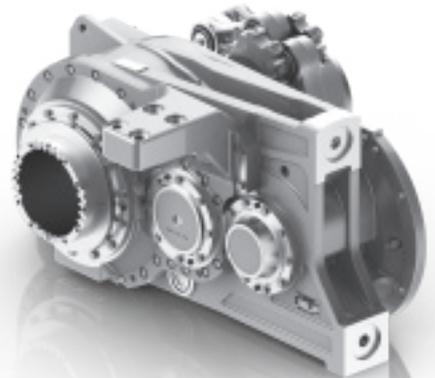
Axle-mounted, single-stage hollow shaft spur gear drive with partial suspension



Axle-mounted, two-stage spur gear drive with partial suspension



Axle-mounted, two-stage spur gear hollow shaft drive with engine connection via rubber bearings



Two-stage, partially integrated spur gear drive with full suspension



Spur gear axle drive



**Metro gearboxes – Highlights at a glance**

- Gearing know-how based on 100 years of experience
- Noise-optimized design
- Weight-optimized design
- Long-standing experience with aluminum housings
- Long service life
- Customer-specific solutions



# Appropriate mobility for life in the city.

City trains and trams, also called light rail vehicles (LRV), make it possible to implement public transport concepts whose capacities and performance characteristics are adapted to the demand of the individual cities. In each case, ZF technology ensures efficient, quiet, and environmentally-friendly mobility.

The increase in traffic is a challenge for cities and transport authorities: On the one hand, mobility within the city must be guaranteed. On the other hand, this should not impair quality of life. ZF driveline technology provides help in walking this very thin line in the form of light, electrically powered rail vehicles. With the reliable, weight and noise-optimized transmissions, city trains and trams ensure energy-efficient and thus both economic and environmentally-friendly passenger transport.

## Reach your destination barrier-free

In order to allow all passengers easy access and passage, the rail vehicles are often designed as barrier-free, i.e. stepless low-floor vehicles. This calls for extremely compact transmission concepts as well as unconventional, vehicle-specific design. For these special solutions in 100 percent or 75 percent low-floor design, ZF offers solutions which are as excellent a fit as its solutions for conventional bogies in high-floor design.

## High performance in Wuppertal

The Wuppertal Suspension Railway has been equipped with a highly-integrated drive system since 2015. The drives consist of one electric motor and two transmissions each which drive the gearings arranged in series. Since the mono-rail suspension railway which was first put into operation in 1901 mostly circulates on a historic supporting framework directly above the river Wupper through residential areas, the focus was on lightweight design, noise development, and leak tightness. The two-stage bevel helical gear with an aluminum housing and a ratio of  $i = 12.4$  is characterized by a high degree of efficiency and a gearing geometry which ensures a considerable reduction in noise emissions and thus considerably improves both passenger comfort and the quality of life of the residents.



### LRV transmissions – Highlights at a glance

- Gearing know-how based on 100 years of experience
- Noise and weight-optimized design
- Long-standing experience in designing aluminum housings
- Long service life
- Customer-specific solutions for low-floor technology or other special vehicles





## The right fit for environmentally-friendly public transport concepts.



Master: single-stage spur gear drive with an intermediate gear and a bevel gear  
 Slave: single-stage spur gear drive with an intermediate gear



Single-stage hypoid gear



2-wheel longitudinal drive with a two-stage bevel helical gear with full suspension



Bevel helical gear with differential

# Powerful mainline and switcher locomotives and special vehicles.

Globalization leads to an increase in passenger and goods transport. Taking the pressure off the roads by means of rail transport therefore not only plays an important role in conurbations but also when traveling long distances. Diesel and electric locomotives with ZF transmissions provide reliable power in this context.

In order to be able to successfully compete with passenger cars and trucks in long-distance traffic, diesel and electric locomotives must be powerful, robust, resilient, and cost-effective. This becomes possible with ZF drive-line technology: The transmissions optimally transmit strong engine power and are powerful, robust, and have a long service life.

Even heavy diesel locomotives accelerate effortlessly with the ZF axle drive. The powerful, low-wear transmission is based on a modular design and can quickly be adapted to fulfill customer-specific requirements. High interface flexibility, cost-effectiveness, and maintainability of the transmission result in optimized life cycle costs.

Highest resilience and endurance are the characteristics of the "Euroshuttle transmission" for six-axle electric locomotives. The one-stage transmission with full suspension has double helical gearing and a BBC universal joint coupling. The pinion is pressed onto the motor shaft and the output gear is supported by means of a tapered roller compact bearing on the hollow shaft

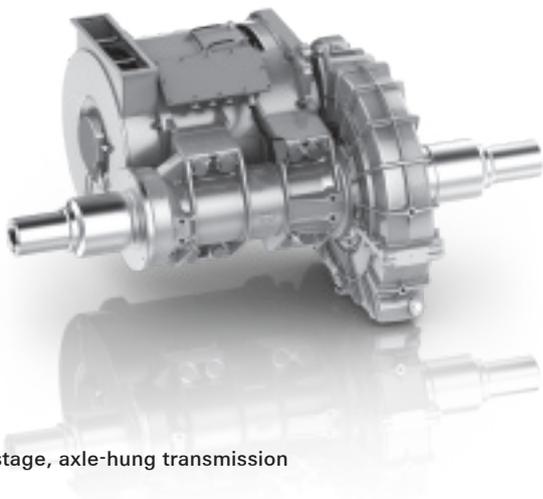
housing. The transmission is both noise-optimized and easy to service, which leads to very high customer satisfaction. For electrically powered freight and passenger locomotives with maximum speeds of 160 km/h and for markets on which low acquisition costs are a key factor, ZF offers an axle-hung transmission in compact design.

## Also convincing on short journeys

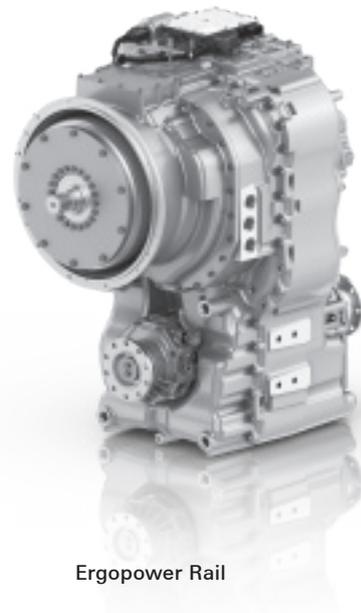
With the ZF Ergopower Rail, a transmission for track laying and maintenance vehicles, ZF has established the benchmark on the market: Smooth running and low load peaks increase service life and reliability and ensure cost-effectiveness as well as ride comfort. High helical gears minimize noise development. Since the axle differential is integrated into the transmission housing, an additional transfer case is not required. Transmissions in the ZF Ergopower series are able to change direction of travel without an additional reversing stage.



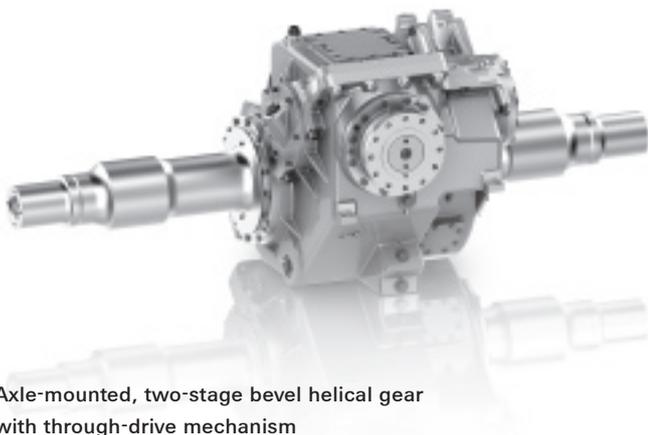
## Resilient driveline technology with a long service life.



Single-stage, axle-hung transmission



Ergopower Rail



Axle-mounted, two-stage bevel helical gear with through-drive mechanism



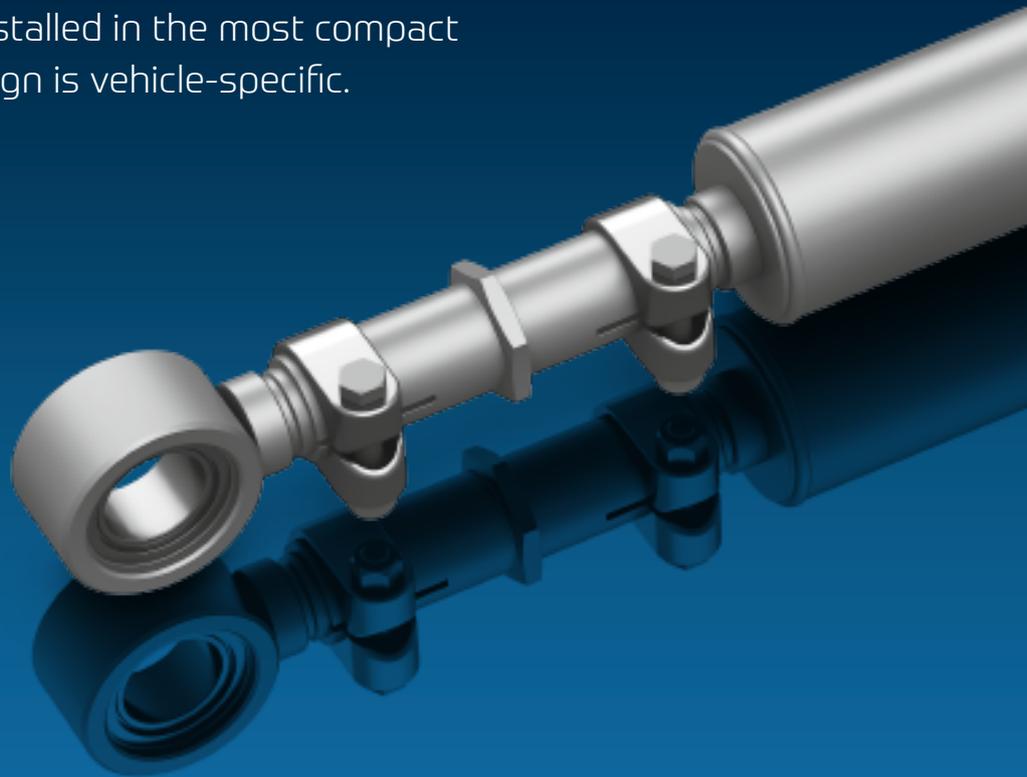
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### Locomotive transmissions – Highlights at a glance

- Long service life and high level of reliability
  - Minimized noise thanks to helical gearing
  - Robust
- .....

# All in one.

The innovative ZF spring damper element increases comfort and safety. Thanks to its innovative technology, this new product can be installed in the most compact installation space. The design is vehicle-specific.

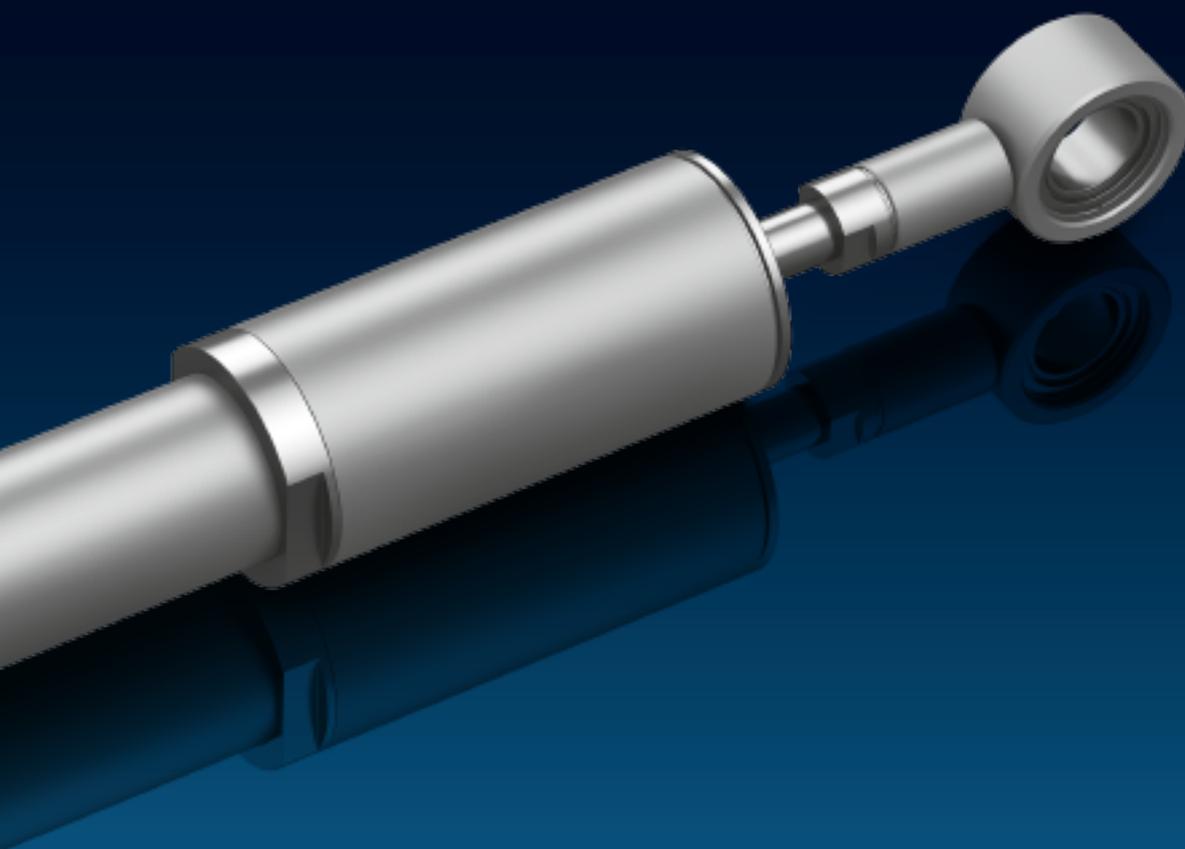


## 2.5 bn €\*

### Investment in Research and Development

Approximately five percent of ZF's sales are invested in Research and Development.

\*Status 2018



In rail vehicles, so-called spring damper elements at the interfaces between the superstructures compensate and control the relative movements of the cars toward each other. The new ZF spring damper element is a special kind of spring damper element. It is used in the head-end of the transitions between the cars and is particularly effective: The innovative damper technology only permits gentle movements and eliminates unwanted, abrupt jolts. The resulting increased anti-roll stability in the train improves passenger comfort and safety.

The objective was to develop a damper element with an overlapping spring rate in rebound and compression. Thanks to the integration of the rebound and compression spring,

the spring damper element is now also optimally suited for rail vehicles with limited installation space. At the same time, the new ZF product can also be flexibly adapted to the respective vehicle-specific requirements. Both damping and spring characteristics can be defined within a broad range in order to fulfill customer-specific requirements. To compensate for tolerances, the length of the dampers in the vehicle can be adjusted.

And last but not least, the transport authorities benefit from this ZF innovation. The spring damper element contributes to reducing life cycle costs: Its absolutely maintenance-free, modular design makes it a convenient and favorable application in all respects.

# Top-performing. ZF rail vehicle dampers.

Increasing train speeds mean higher requirements for damping systems in rail vehicles. In close cooperation with its customers, ZF develops innovative, efficient concepts which are easier on both people and materials.

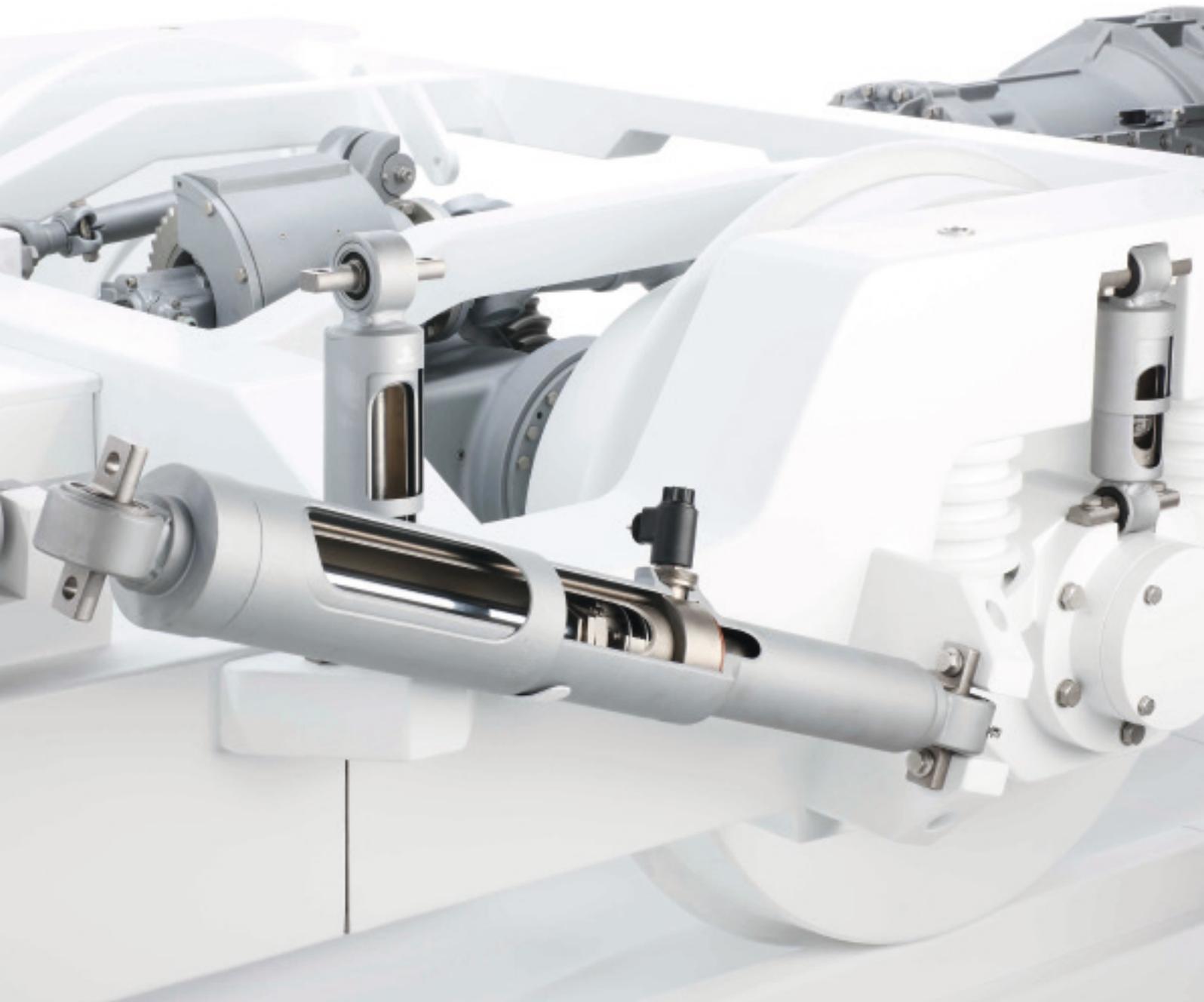
## ZF primary and secondary dampers

Primary and secondary dampers are maintenance-free twin-tube dampers in modular design and are available in two sizes. Their variably adjustable damping valves make it possible to implement the most diverse required damping characteristic curves and force levels. The usually vertically designed primary dampers reduce vibrations which originate between the axle and the bogie during driving, which greatly increases anti-roll stability and safety in the train. The vertically or horizontally designed secondary dampers improve ride comfort by damping vibrations between the bogie and the superstructure. Their special design prevents air from entering the working chamber, particularly in case of horizontal damper design. In vertical design, both primary and secondary dampers are available with an optional integrated lift stop which holds the axles on the bogie and/or the bogie on the superstructure when the vehicle is put onto the rails.

## ZF yaw dampers

Yaw dampers control the sine wave effects of the bogie, increasing safety at medium and high speeds. In order to meet market requirements, ZF offers several technical designs: These are based on the twin-tube principle, the recirculation principle, or the principle of a synchronized speed cylinder. All versions come with block safety. Electrically controlled yaw dampers are an advantage on winding rail tracks. Their damping function is switched off during cornering, which considerably reduces the contact forces between the wheels and the rails and results in considerably less wear. As a consequence, vehicle and rail maintenance costs are much lower.





## ZF spring damper elements

Spring damper elements improve the train's anti-roll stability. They are special variants of the maintenance-free ZF horizontal damper and are used between coupled together superstructures. Their job is to harmonize the relative movements between the superstructures. This translates into an extremely high level of ride comfort and at the same time positively influences the vehicle's anti-roll safety.

## ZF special dampers

ZF also produces dampers for special applications in the areas of running gears, superstructures, and drives. Based on the requirements, these special dampers are modified based on the standard portfolio or specially developed. In this way, yaw dampers can for example be used as coupling dampers in bogies with coupling frames. Horizontal dampers can also be used as engine dampers. Spring damper elements are offered for the transitions between the cars.



# Chassis technology for multiple applications.

The ZF product portfolio for chassis components is versatile and flexible. The individual products can be tailored to the respective application and task.

## ZF stabilizer links

The stabilizer link serves as an anti-roll stabilization or as torque support. If it is used as a flexible connection for anti-roll stabilization, it transmits the forces from the bogie to the superstructure. It can be designed with either a vibration-absorbing rubber-metal bearing or a plain bearing free of clearance and can be manufactured with both adjustable and fixed length. If the stabilizer link is used as a transmission support in the bogie, it is referred to as torque support. In this function it also acts as a vibration-absorbing bearing. Thanks to its modular design, the stabilizer link can be flexibly adapted to fulfill customer requirements without long development times. The customers benefit from short delivery times.

## Adjustable ZF v-links

The adjustable v-link by ZF is a flexible connection for superstructures. Installed in the bellows area, the ZF chassis module transmits longitudinal and lateral forces. Thanks to its adjustable length and modifiable spread angle, it can be adapted to various connection systems without any problems. Another benefit: V-links reduce noise and improve ride comfort. The design of ZF products is based on the respective customer specifications.

ZF chassis components adapt to their respective task.



Horizontal damper



Vertical damper



Yaw damper



Electrically controlled yaw damper



Spring damper element



Stabilizer links



# Comfort and safety on track with ZF.

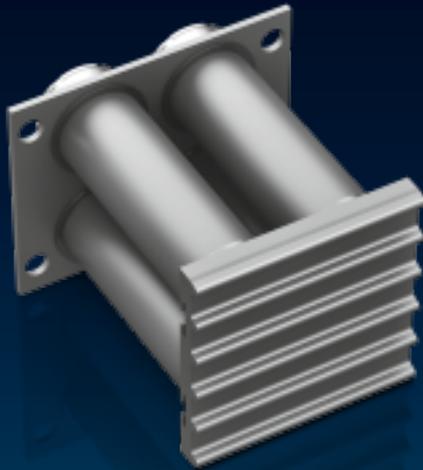
ZF offers chassis technology which effectively increases passenger comfort and safety. One example is the ZF crash system which ensures rail vehicles meet standard collision safety requirements (EN 15227).

## ZF Crash System

In case of rail vehicle collisions, the ZF Crash System increases passive passenger safety. The modern system which complies with the standards is based on hydrodynamic impact absorbers mounted on the vehicle's front end which absorb impact forces reversibly or irreversibly depending on the force of the collision. In case of low-impact collisions which, for example, occur during parking and maneuvering, the absorbers absorb the impact forces and remain undamaged.

In case of high-impact collisions, they effectively convert the high energy which is generated by the impact into heat. After this irreversible process, the absorbers are no longer functional and have to be replaced. Thanks to its modular design, the ZF Crash System can be flexibly designed to fulfill customer requirements, based on the respective force levels and on the type of rail vehicle. It is suitable for all rail vehicle types.

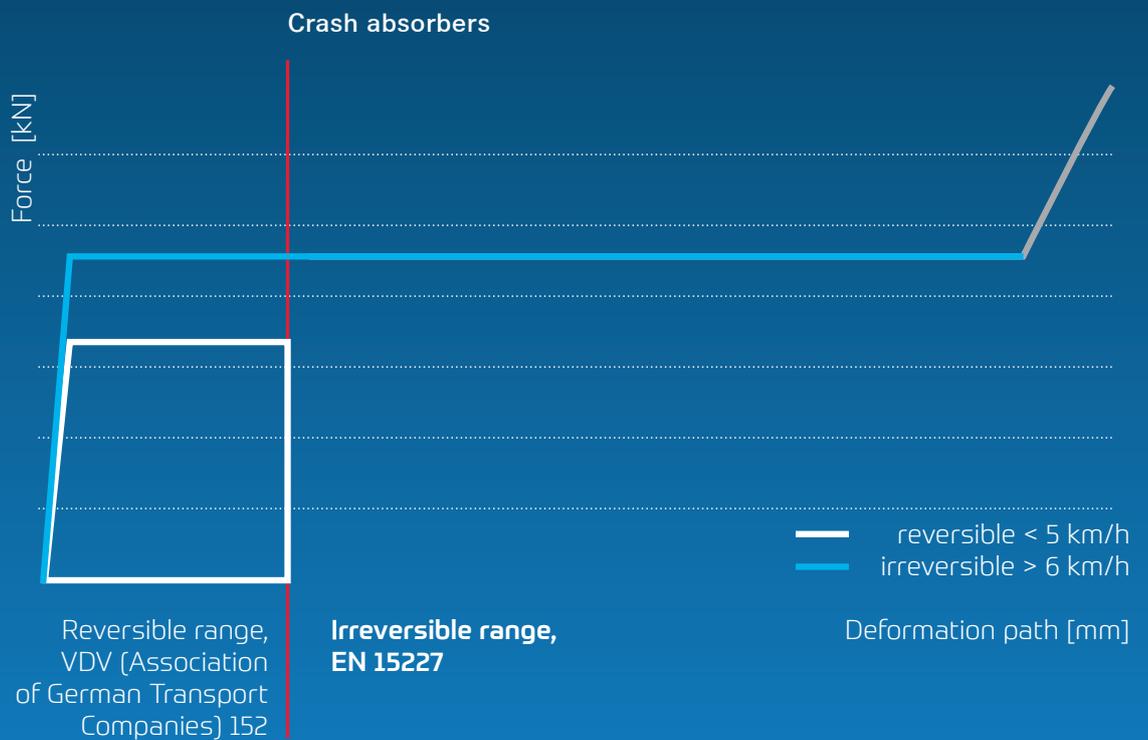
The ZF Crash System. Appropriate protection in case of low- and high-impact collisions.



4-tube energy absorbers



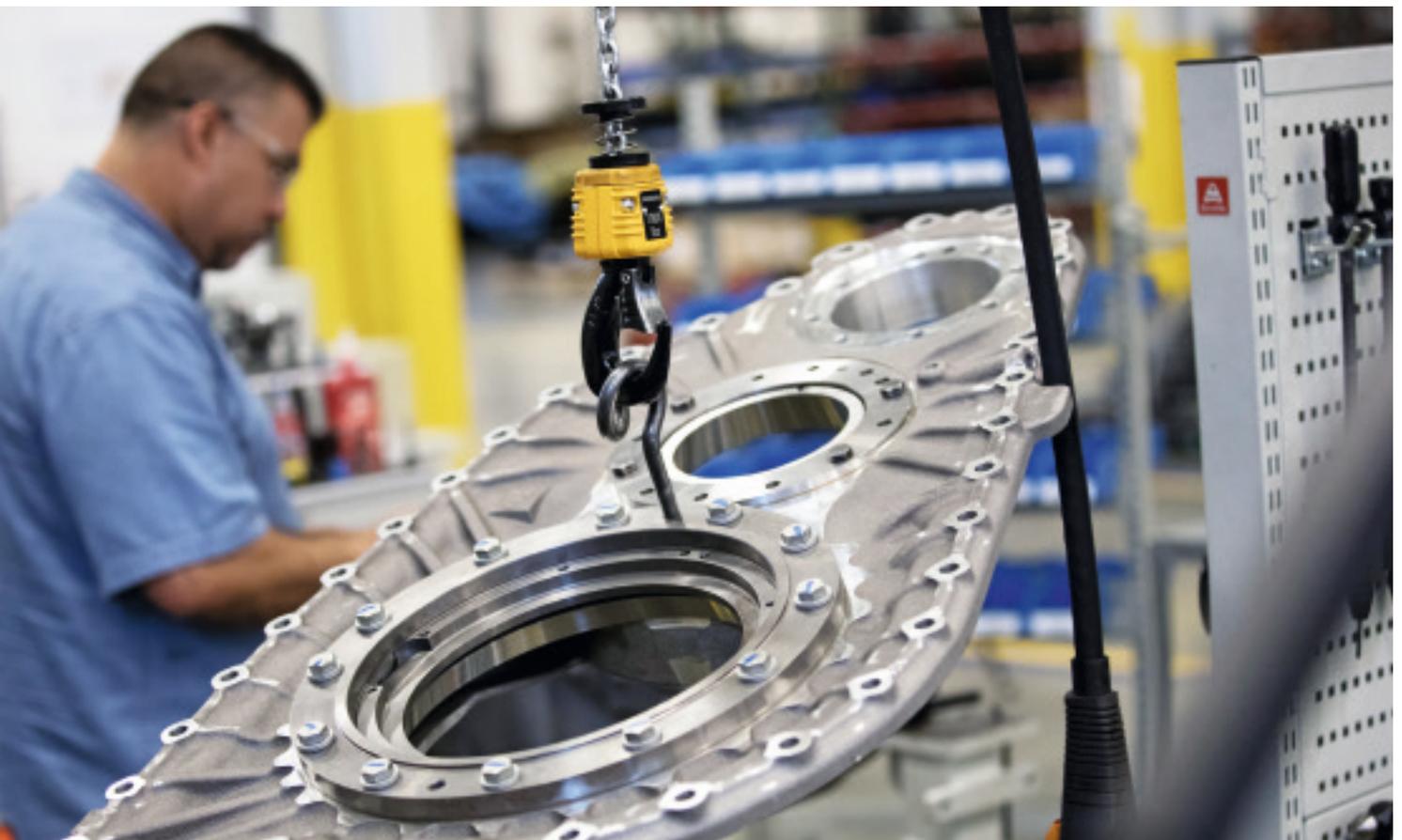
Crash absorbers



Crash absorbers can be used for the reversible and the irreversible range; 4-tube energy absorbers are designed for use in the irreversible range.

# Globally mobile. ZF Aftermarket.

Trains in passenger and goods transport are in operation for an average of 30 years. The enormous forces occurring during this, very often millions of kilometers, requires not only product quality but also maximum service quality.



From immediate spare parts supply and technical information to flexible services: With its attractive service portfolio from a single source, ZF Aftermarket directly continues ZF's system competence in the aftermarket. Worldwide!



As a leading global technology company, ZF is not only perfectly positioned when it comes to driveline and chassis technology and active and passive safety technology, it is also a reliable partner in the service business. The ZF Aftermarket division offers demand-driven service solutions not only for automotive customers, it is also a one-stop shop for off-highway, rail, industrial, marine, and wind energy applications. From quick spare part supply and technical service to consulting and training, ZF Aftermarket carries forward ZF's system expertise into the aftermarket, thus ensuring vehicle and product performance and efficiency throughout their entire life cycle. After-sales experts from ZF are available worldwide at 120 locations, 90 logistic centers as well as with 650 service partners.

## Making headway reliably

Service centers operated by ZF Aftermarket offer preventive overhaul, maintenance, servicing as well as driveline and chassis technology conversion and retrofitting in rail vehicles. They also service ZF and multi-brand transmissions as well as provide a comprehensive assortment of

ZF replacement units to minimize downtimes. To give an example: In the process of overhauling transmission systems, the exact wear condition and the optimal overhaul scope are determined by means of a comparison with reference transmissions. This avoids unnecessary work and costs. If operation is to continue without interruption while the old transmission is being overhauled, ZF Aftermarket also offers to temporarily equip the vehicles with a replacement transmission. The service portfolio also includes a fast and guaranteed supply of spare parts, which are sold by ZF Aftermarket exclusively in OEM quality. These parts are produced and inspected according to the identical specifications used for volume production. This guarantees top quality.

Of course, ZF Aftermarket also repairs and services product systems or system components from other manufacturers. ZF service partners repair and overhaul multi-brand transmissions in OEM quality and cooperate with partners from industry as the central contact for the customer.

# Think globally, act locally.

Internationality is more than just selling products worldwide. ZF has known this for a long time. With the inauguration of the first production facility outside of Germany in São Caetano do Sul, Brazil, in 1958, the company already started to work on what is today referred to as globalization.



ZF technology moves people worldwide. And it is produced globally as well. With currently 230 production companies in 40 countries, ZF has long since become a global player which is represented on all continents – and always acts locally there as well. The products are tailored to meet local market requirements and are, as much as possible and taking into account the respective local content provisions, industrialized in the region where they will later be used. This also applies to driveline and chassis technology for rail vehicles. The metro gearboxes for the Los Angeles city trains is volume produced at the ZF production location in Gainesville, USA. It was designed in cooperation between employees

in Gainesville and engineers in Friedrichshafen. In the process, the team equally benefited from being very close to the market and from Group-internal experience in matters of materials engineering, FEM calculations, and acoustics expertise. To give another example: Transmissions and dampers for the Chinese market are also produced locally. Dampers are produced at the production location in Shanghai, China. In Beijing, China, assembly lines for the production of ZF Highspeed and metro gearboxes were installed. Moreover, a local representative office takes care of sales, project planning, and technical support. The objective is to optimally develop the rapidly growing Chinese market.



Find your nearest service location and go to [www.aftermarket.zf.com/rail](http://www.aftermarket.zf.com/rail)



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