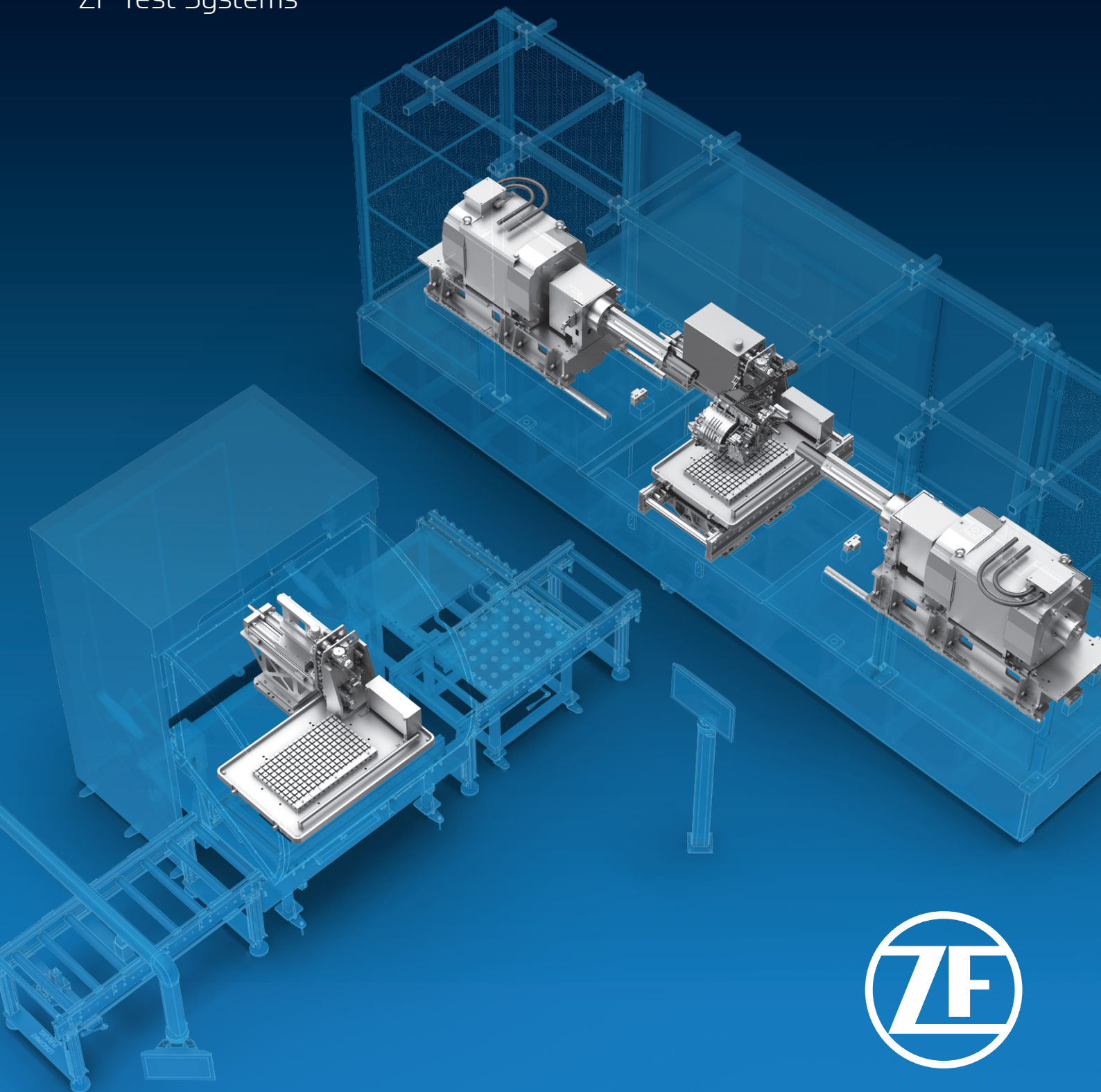


# Future mobility. Tested now.

ZF Test Systems



# Your products on our test system

We cannot imagine research and development, production and quality assurance or service without efficient test facilities. They help save time and money and ensure an ever increasing quality.

## System supplier for many business fields

Powerful test facilities are essential in research and development but also in current production. They allow the development cycles to be shortened, cost to be lowered, series production to be controlled reliably and they enable you to offer the service required by your customers.

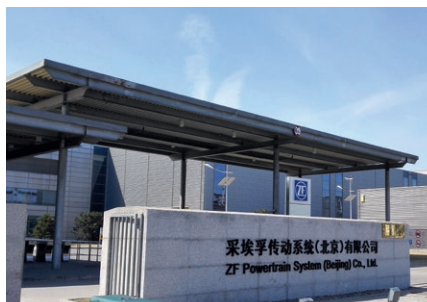
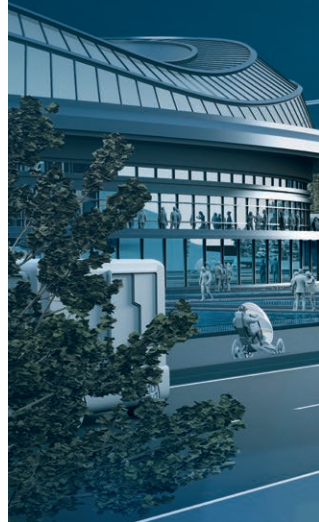
ZF Test Systems develops and produces test systems for on- and off-road mobility. As specialists for validation and development test facilities, we improve the quality of driveline, active chassis, tires

and wheels as well as brakes and thus contribute to enhanced safety and comfort for the driver. Besides that, we offer DC power electronics based on SiC for simulating and testing batteries.

Our product range covers the full span from individual test benches to complete test lines, focusing on applications like e-mobility, transmissions and axles, tires and wheels, brakes, transmission components and oils.

## 35 years of experience

The business unit Test Systems which is located at Passau relies on



ZF Test Systems' main assembly site and headquarters is located at Passau, Germany (left), the second production plant in Beijing, China.



## TEST SYSTEMS FOR



Transmissions  
and axles



Brakes



Components and oils



E-mobility



Battery simulation  
and testing



Tires and  
wheels



more than 35 years of experience in the construction of turnkey test facilities. Meanwhile over 1,600 test systems have been supplied to satisfied customers in 40 countries worldwide.

For us, there is no conflict between well-proven technology and innovative solutions. Rather these are the recipe for a reliable, customized test rig technology exactly tailored to the customer's specific requirements. We see ourselves as a complete system supplier and problem solver; with the experience and creativity of our employees we know the customer's needs and requirements, and find the ideal solution together.

### Part of a strong group

Test Systems is a business unit of the ZF division Industrial Technology. In this division, ZF bundles its activities for "Off-Road" applications. It comprises the development and production of transmissions and axles for agricultural- and construction machinery as well as driveline technology for material handling systems, rail- and special vehicles. The division is also responsible for the worldwide business of marine propulsion systems, aviation technology as well as the development and production of gearboxes for multi-megawatt wind turbines.

The business units of the Industrial Technology Division thus cover a wide range of products and markets. The Division employs a total workforce of approx. 10,000 persons at 26 locations worldwide.

All ZF corporate divisions have production systems which are matched to the market-specific requirements. The six principles of these production systems are standardization and flexibility, process orientation in customer-supplier-relationships, just-in-time, employee and team orientation, zero-error, as well as innovation and continuous improvement. The strict focusing of the company towards value-added processes along with the upgrading of all processes and products by innovations are the basis for customer benefit by leading technology.

### Future mobility. Tested now.

Driven by the force and competence of a globally active engineering group, we are developing solutions for the future mobility and are prepared for the forthcoming requirements like autonomous driving and E-mobility. We recognize sustainable trends early, and are providing our customers with solutions to secure competitiveness also in the future.

# Tailor-made turnkey solutions

As a specialist for electric vehicle and tire technology we know what is important in practical application. We deliver turnkey test facilities, including all peripheral systems and software, so they are immediately ready for use and operable.

## One source for everything

As a systems supplier our product range covers the full span from standard test benches to complete customized test lines. We are taking care of everything, from development and planning via manufacture, assembly and programming of the test benches, right through to their equipment with peripheral and supply technology. We offer our customers an individual, flexible and rapid project management. All facilities are manufactured and tested in ready-for-use condition in our assembly workshop.

## Tailor-made solutions

Depending on the customer's requirements we create individually tailored test systems after having developed a matching concept in coordination with the customer. Thanks to many years of experience ZF can use well-tried basic modules for most projects. This does not only accelerate the development time but guarantees highest functional safety. So the customer benefits twice: Within shortest time he gets a sophisticated test system at low cost which includes components that have proven themselves in thousands of applications.

## Immediately ready for use

As a specialist for driveline and chassis technology we know what is important in practical application. We deliver turnkey test facilities, including all peripheral systems and software, so they are immediately ready for use and operable. The customer gets comprehensive

instructions and an in-depth training of all test procedures. After commissioning of the test systems, the customer can further rely on the expertise of ZF. A remote connection allows wide maintenance. Additional support is offered by the ZF-Helpdesk, with our experts from the fields of mechanical engineering, electrical engineering and software programming providing assistance on the phone and on site.

## Comprehensive customer support

We know the importance of high-tech test systems for our customers, especially when they are directly integrated into the production process. Our range of services is focusing on these requirements. We offer our customers rapid and straightforward support in case of urgent need or as part of maintenance and service contracts. Consequently a smooth operation of the test facilities after delivery is guaranteed at any time. A maintenance contract is the safest way to ensure smooth operation even after many years, since regular maintenance and calibration are the key factors to secure reliability and quality. Customers who want to carry out maintenance and repair work by themselves can attend an advance training course held by the staff of ZF Test Systems. Based on this training and using our extensive documentation they will then be able to take care of the service work. The required spare parts will be supplied by us rapidly.





#### Road-to-Rig test system

ZF indoor dynamic road simulation test bench for complete vehicles or powertrains.

## Test systems for powertrains

**Flexible R&D test technology – fully automatic test lines.** As a specialist for the development and production of powertrains and axles, we know what is important when testing drive systems. ZF serves a wide range: from passenger cars, vans and trucks to heavy construction and agricultural machinery, from a single test bench to a fully automatic test line for manual, automatic, CV transmissions, e-mobility or axles. ZF develops, produces and delivers R&D and production test systems for customers worldwide.

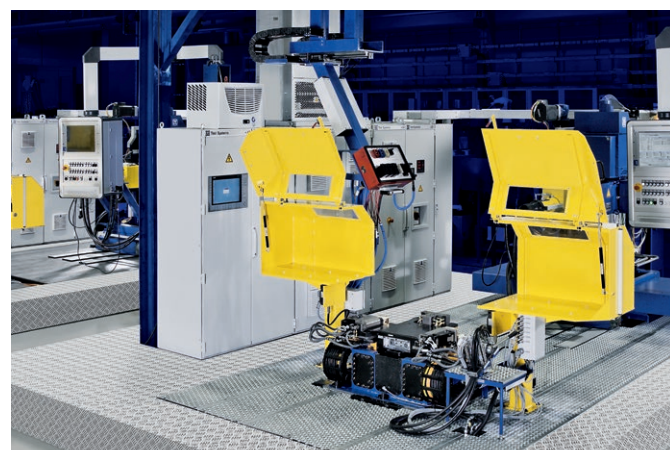


#### Advantages

- Fully automatic testing of various parameters as function, service life, efficiency, acoustics, ratios, shift quality and leak tightness
- R&D test systems that are flexibly controllable and variable in size enable a high reproducibility of test conditions
- Function tests, quality assurance and high operational capacity.

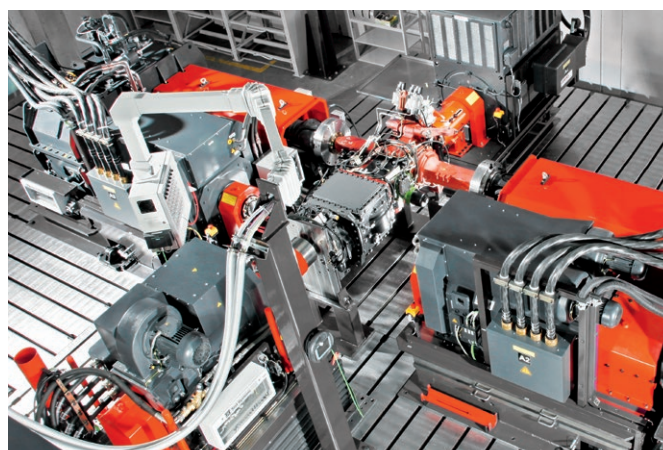
#### Production test system

Customized end of line production test system for the off-highway industry with highest grade of automation and precision.



#### R&D driveline test system

Fully automated R&D test system for entire drivelines up to 800 kW with high dynamic drives.





# Innovations of great value

We are aware that our customers expect optimum solutions in every respect. Therefore, ZF Test Systems is continuously enhancing its test systems which will help the customers gain the advantage over their competitors under hard competitive conditions.





## dustIN

The planned legislation in the form of a new EURO standard based on the current status will include and regulate non-internal combustion engine particulate matter in addition to the stricter exhaust emission limits. The standard is expected to include both limit values for the mass of brake particles emitted and the number of brake particles.

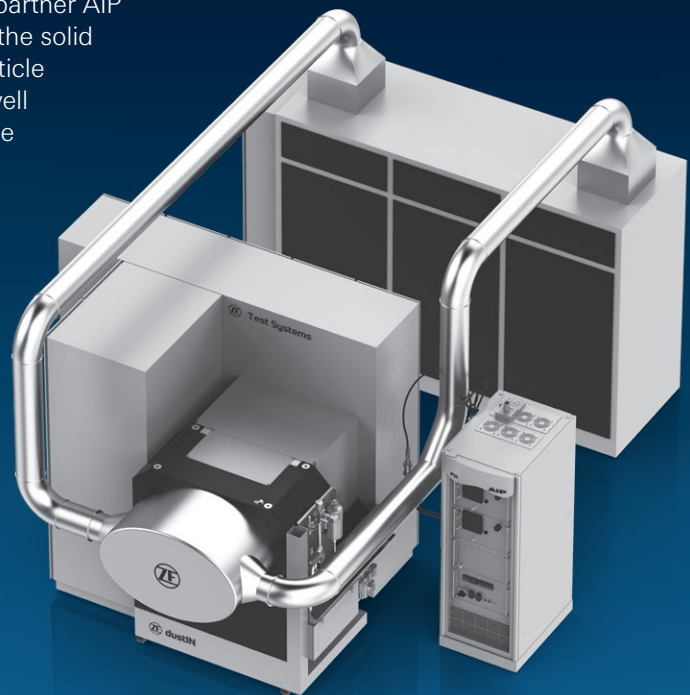
In order to investigate the influences (e.g. material pairing, driving cycle, temperature behavior, recuperation, etc.) on the emissions behavior of passenger car vehicle brakes, we need realistic, reliable and reproducible test bench measurement data.

The ZF test bench "dustIN" (Dust Investigator) can achieve any desired driving profiles such as WLTP Brake or California Brake Dyno Cycle (CBDC) by simulating the required vehicle inertia using superimposed electrical mass simulation.

Due to the downstream isokinetic sampling (according to ISO 9096) of a partial flow by proven and adapted particle measurement devices from the exhaust emission measurement of our partner AIP Automotive, the solid and total particle number as well as the particle

mass in the fractions  $PM_{10}$  &  $PM_{2.5}$  are measured.

Thanks to the modular design in the driveline, we offer different performance classes - from the PMP variant to the R&D test bench with extended temperature ranges and performance characteristics. The layout is customized so that the compact and modular design results in a minimal footprint of the overall system.



## ZF T-Wear: Our eco-friendly test bench for tires

Tires lose substance over time and release tiny particles, for example in the form of microplastics. This abrasion is a contributing cause of pollution in cities and one of the sources of microplastics in the environment. Using the ZF T-Wear enables tire manufacturers to test the tire abrasion and to optimize their tires, thus contributing to a cleaner environment.

The ZF T-Wear allows the simulation of real driving profiles on the test bench to classify the wear behavior of a tire at regular intervals.

ZF's new Tread Wear Tester can be operated 24 hours, seven days a week, regardless of weather conditions. The "Indoor Testing" also allows better and controlled simulation of the temperature, driving speed and road surface, removing the driver's influence.

ZF has developed a new measurement system that allows laser measurement in the high-frequency range. The ZF In-Line Tread Wear Mapping System measures the tire abrasion at the tread. The measurement is fully automatic in the ma-

chine, i.e. the tire no longer needs to be removed from the machine and measured separately.

With this "Powder Supply Unit" installed, the natural friction caused by pollutions on the road, such as dirt and dust between tire and road surface, is simulated close to reality. The Tread Wear Tester enables the simulation of various driving modes, which are adaptable to customer-specific driving cycles by a flexible system.

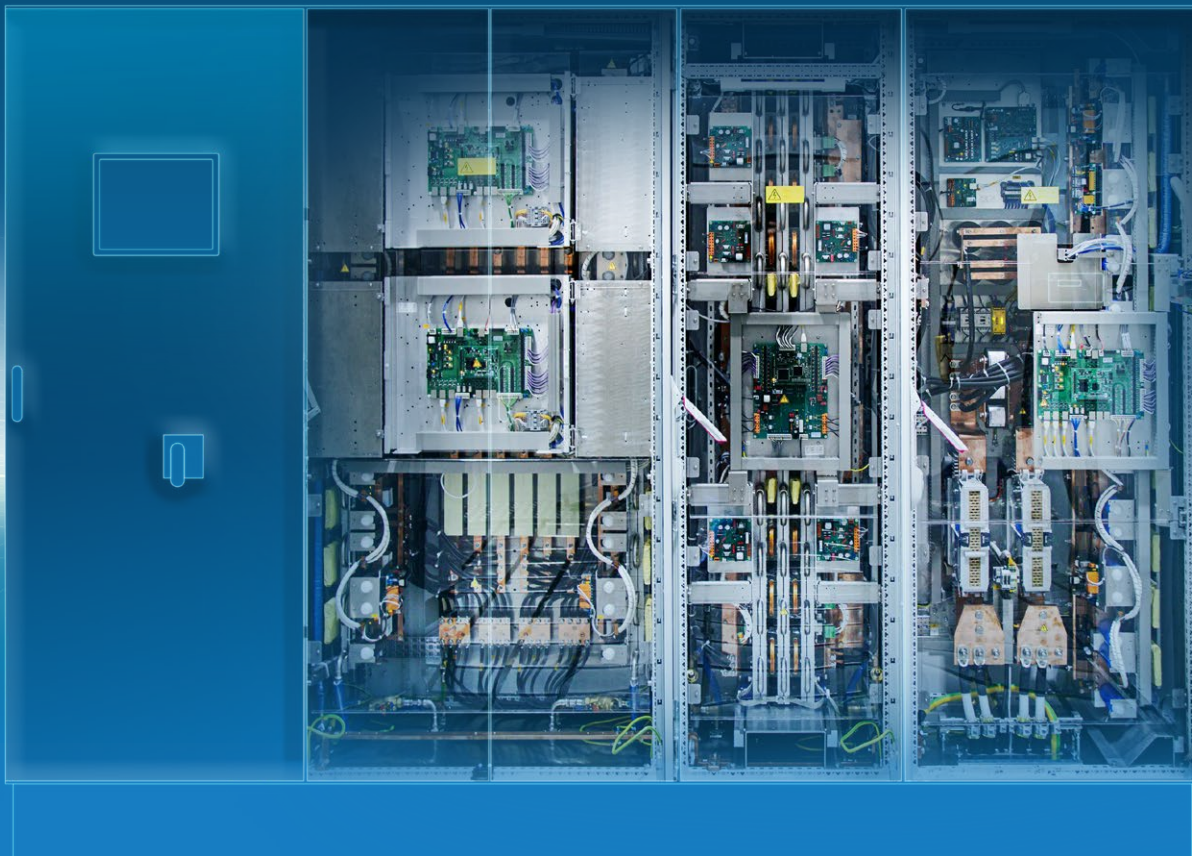
## ESYS – battery simulation and testing

ESYS can simulate a wide variety of battery models in a highly dynamic manner at different voltage levels – from a simple internal resistance model to complex R-L-C models. This makes our battery simulator an important component of e-mobility test benches.

In the field of battery testing, we can offer a broad portfolio covering all battery types – from cell, module to pack. ESYS can also be used for tests of power electronics, Supercaps or even for fuel cell tests.

ESYS provides a wide power, current and voltage range (2 kW ... 1 MW / 8 V ... 1500 V / 100 A ... 1600 A) with a dynamic power of >1 MW/ms. The power ratings can be further increased by parallel connection. Our DC power electronics are based on SiC and thus increase the efficiency of ESYS.

Additional measurement ranges for current and voltage provide more flexibility and accuracy.





## Road Belt Tester ZF-RB 5

The Road Belt Tester ZF-RB 5 simulates driving and kinematic conditions on a flat surface to deliver data for tire modelling and to evaluate tire performance data.

Modern vehicle development is increasingly taking place in virtual reality. It is based on a mathematical model of the future vehicle and the associated tires model. The tires as an essential component of a vehicle are treated as separate mathematical models.

Before the tire model can be used in simulation environments, the theoretical properties of the tires must be compared with properties that have been measured. Tire test benches such as the Road Belt Tester are essential for doing such real tire measurements.



The Road Belt Tester ZF-RB 5 has remarkable advantages for demanding measurement tasks:

- The movements of the wheel is freely definable
- The setting precision is excellent even under full load condition
- It enables exceptional dynamic set values and a greatly improved dynamic measuring range
- By using parallel kinematics static spring characteristics can be measured in all axes

## Reliable high torque/speed e-mobility test bench

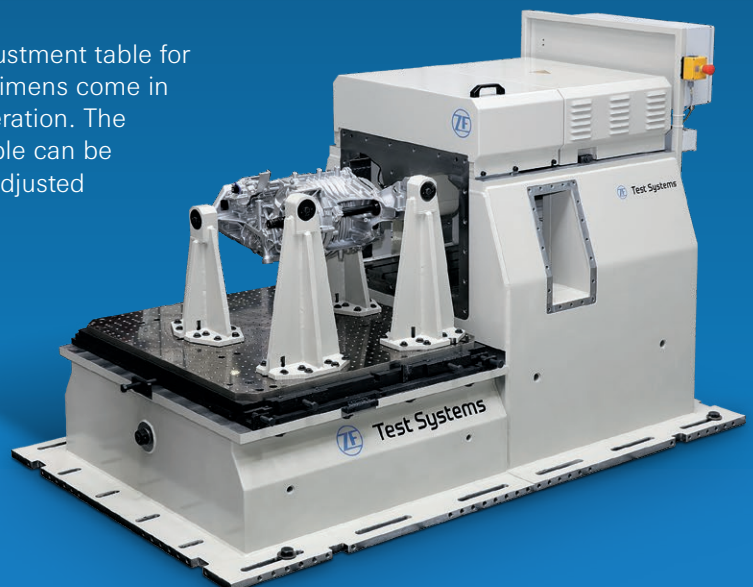
We have refined our well-known e-mobility test bench set that can be used to test complete electric drive axles, electric motors and electric axle drives. The core component of the modular structured test bench is a drive module with an oil-cooled synchronous motor, which is now capable of delivering powers up to 750 kW, torques up to 1,200 Nm and a speed up to 26,000 rpm.

The base for the receiving module is optionally fixed, inclinable and swiveling and available for single or multi-machine operation with or without cross table. Various optional modules complement the modular system. A receiving module for electric motors and one for coaxial test objects extend the possibilities of the test bench. An acoustic cabin for the drive module and an air conditioning cabin for the receiving module for the test object are also possible.

Due to the modular design, tests of conventional car transmissions can similarly be performed. The appropriate frequency converter and measurement technology, automation and a highly dynamic control perfect the system.

The new adjustment table for the test specimens come in its third generation. The mounting table can be individually adjusted

in five directions without mutual influences. Adjustment is carried out via five fine-thread spindles for an adjustment to two hundredths of a millimeter.





**E-mobility test system** up to 750 kW / 1,200 Nm torque for e-motors, gearboxes, e-axles, e-powertrain, e-transmissions.

## Test systems for e-mobility

**In a league of their own for the future of mobility.** Electromobility is one of the biggest trends in the industry today. That not only results in changes to components and drives, but also brings with it completely new demands for test benches used to test e-mobility components. Our e-mobility test rigs are real all-rounders: they can test entire drive axles as well as electric engines, and electric axle drives without an engine. Even conventional components for passenger cars can be tested on our e-mobility test benches. ZF offers End-of-Line as well as R&D test benches for electromobility. Each of our test benches is unique: thanks to their modular design, we can react flexibly to special requirements and customer requests.



### Advantages

- Test benches for e-motors, gearboxes, e-axles, e-powertrain, e-transmissions
- Slim design
- Multiple installation options
- Acoustic / NVH package (optional)
- Air and media conditioning option



### Road-to-Rig test system

ZF indoor dynamic road simulation test bench for complete e-cars or e-powertrains.



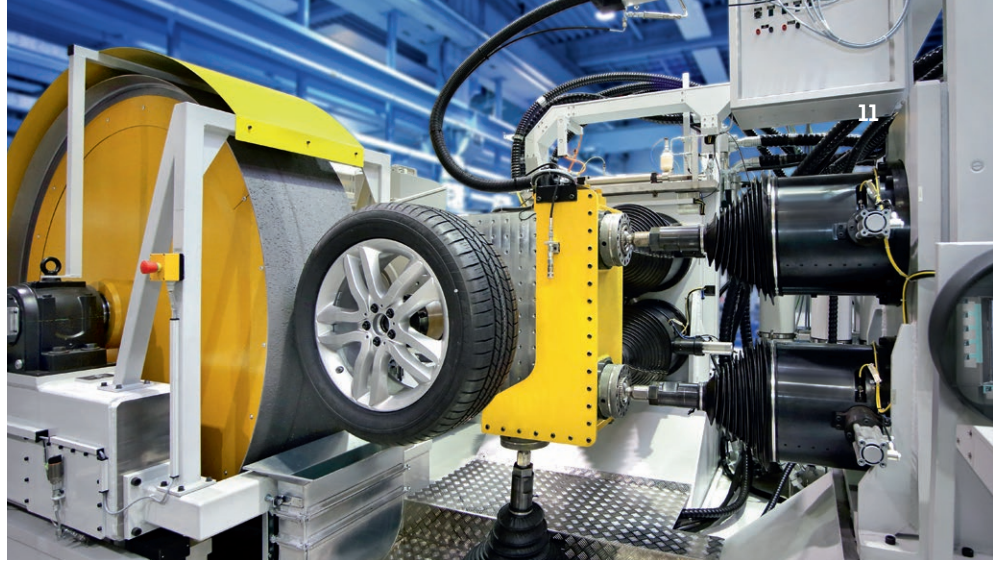
### EoL e-mobility test system

The production test bench for series production allows complete electric drive axles to be tested.



### Multi axial wheel tester

The state-of-the-art multi axial wheel tester (MARF) allows extremely realistic simulations of test piece characteristics. As a result, completely new areas in the dynamic response and in the qualification of measured values can be tested.



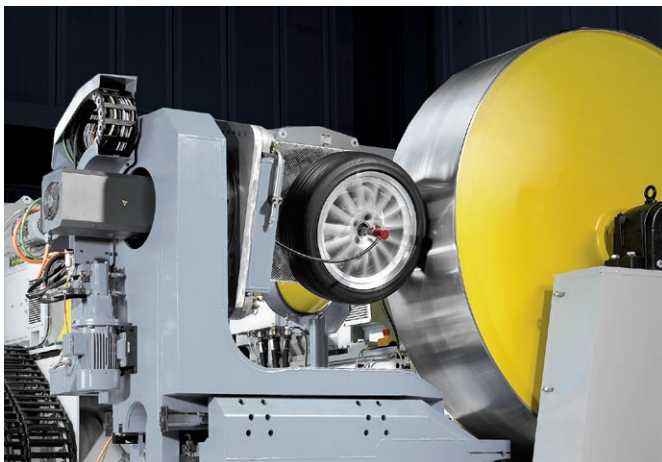
## Test systems for tires and wheels

**ZF provides for comfort, safety and quality.** Tires and wheels are delicate and severely stressed parts of a vehicle. ZF supports customers in the engineering of products already during the development of basic characteristics such as durability, tread wear, rolling resistance and tire characteristics. The size uniformity (low and high speed) which is relevant for vehicle comfort can be measured in this early stage already. In tire production, the limit values of uniformity and unbalance are secured on fully-automatic ZF machines.



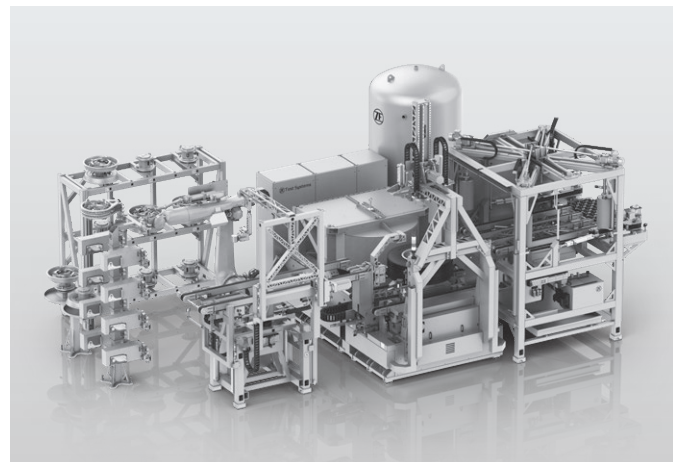
### Advantages

- Highest quality of measurements at speeds up to 400 km/h
- Reproducible simulation of real environmental conditions
- Simulation of real driving conditions for optimization of performance and durability
- Low energy and maintenance requirement during production controls
- Quick and reliable final inspection since all significant quality characteristics can be tested with one single test system



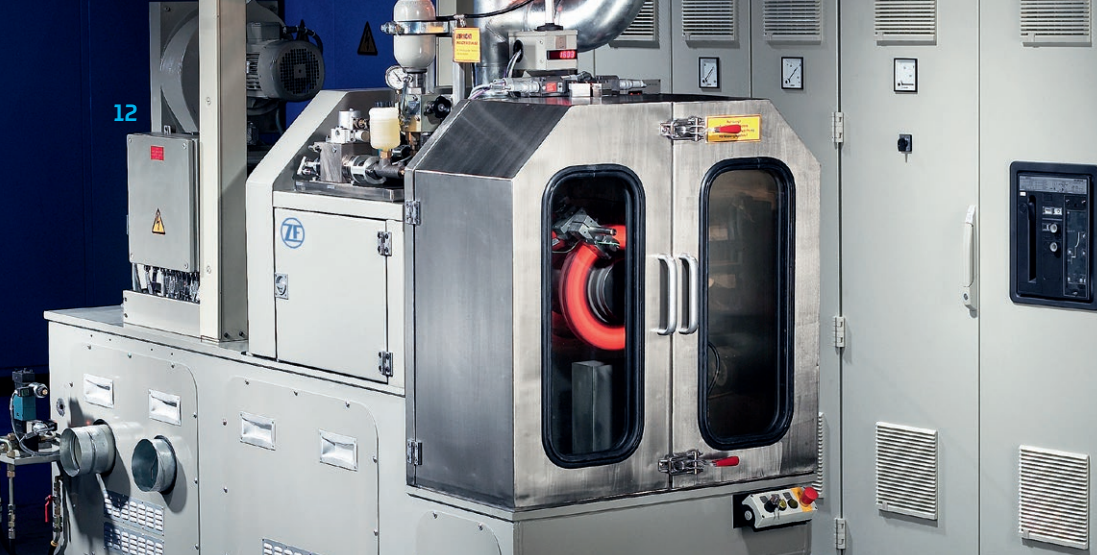
### Force and moment tester

It is highly dynamic on all axes and allows a very fast positioning at high precision. It offers drive file simulation.



### Final finishing machine LUB6 TBR

The ZF-LUB6 TBR is the new final-finish tire test equipment for the inspection of truck and bus radial tires.



#### Compact brake dynamometer

A compact standard test bench for brake development up to a vehicle weight of 3,500 kg and a vehicle speed of 300 km/h.

## Test systems for brakes

### More safety thanks to ZF precision.

There is a great potential for development in the field of brake technology – just think of electronic control systems, enhanced low-wear materials, or reduced brake noise. To bring new product developments up to an economical and reliable series production level, precise high-tech test systems are required, tailored to the individual needs of our customers. ZF supplies brake test systems for passenger cars, motorcycles, commercial vehicles, construction machinery and heavy rail vehicles.



#### Advantages

- Testing of complete brake systems, including corresponding control unit
- Real-time simulation of drag forces, vehicle masses and speeds
- Reproducible simulation of real environmental condition
- Performance testing to performance limit of materials used



### Brake emission tester dustIN

The ZF brake emission tester dustIN offers a turnkey solution for end customers such as vehicle manufacturers, brake component manufacturers as well as independent testing service providers.





#### ZF GLP2 wet clutch test system

A wide range of single or multiple wet clutches can be tested of ZF Stands.

GLP2 tests for large sized friction discs.

## Test systems for transmission components and oils

#### Perfect units into the last detail.

Single components of drive units must also be carefully checked to avoid hidden errors. On the one hand, components must be tested separately with regard to their operability, load capacity or perfect functioning; on the other hand, it is important to analyze their functioning within the complete drive system. ZF offers concepts for a separate component check, but also for function tests of complete systems under realistic conditions.



#### Advantages

- Simulation of real conditions
- Standard test systems allow comparable test results with uniform general conditions (ZF GK test system, ZF FZG standard synchronizer test system SSP180)
- Individual, with the customer coordinated solutions for a wide variety of applications and test parameters



#### ZF GK4 test system

Automated wet clutch test system with latest torque and high dynamic drive technology.

# TESCON – a new automation platform



## Integrated and networked test stand operation has never been easier and faster

We have developed a new highly flexible, intuitive and user-friendly automation software system that is capable of supporting Industry 4.0, to control and monitor a test cell with multiple dynamometers and subsequently, multiple test cells with multiple dynamometers. The automation software runs on an industrialized and proven scalable multi-core computing platform, which includes a real-time engine, that is capable of executing different automation tasks with responses up to 10 kHz. This means that within a 100 microseconds duration,

Customer defined distribution on available cores



### TESCON Studio

Workbench (Configuration)  
Cockpit (Operation)  
Evaluation

### TESCON Artifact

Runtime System  
Real-time Components

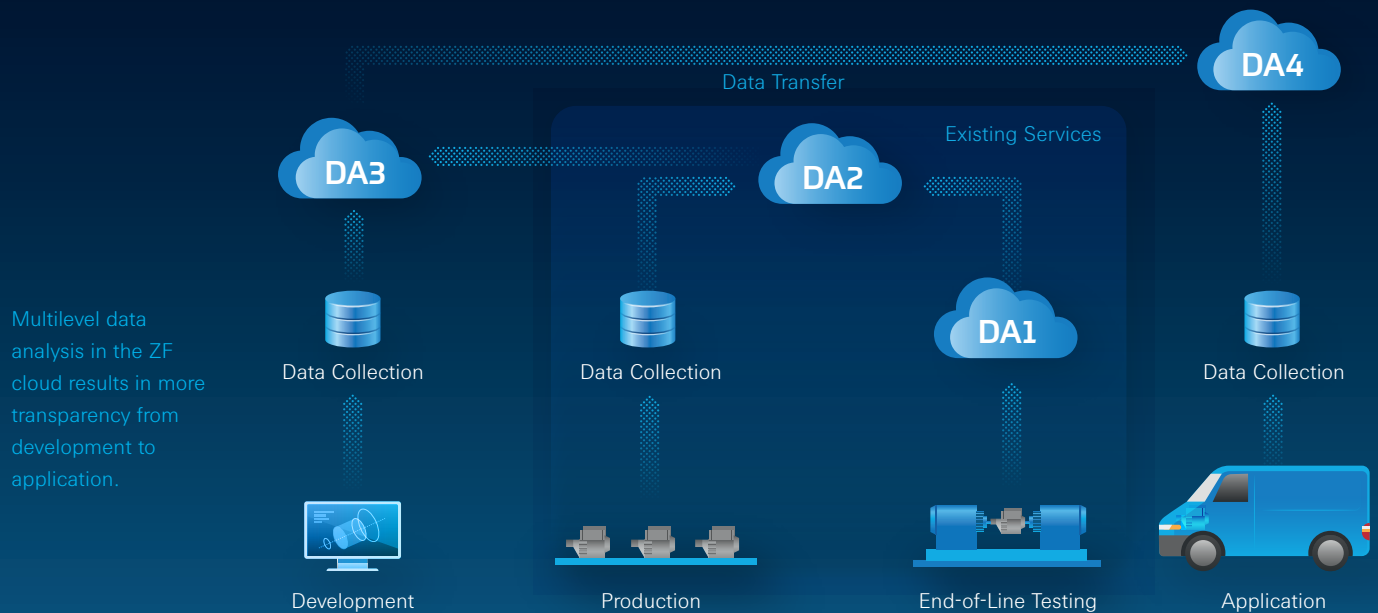
incoming signals can be read and processed, and the corresponding output signals can be updated.

Starting at the top, a Solution created within Tescon runs on the real-time computing hardware. It contains all the necessary modules for the operation of the test bench. The Solution contains a System Program that controls the basic functionality of the test stand, and the Application Program that runs specific tests on the Device Under Test DUT, with its associated channel configuration, test program, views, data recordings, monitoring and parameter set.

The end user uses the Cockpit interface to run a test bench. It loads the test bench with solutions that contain applications, runs the system and test programs and displays the defined views and widgets.



# Your value with data analytics



## Increased quality and efficiency thanks to data analytics

An improved and more effective evaluation of a product's data during its life cycle can reduce costs while at the same time enhancing quality of both the current product and its successor. This requires a linkage between the data from the fields of R+D, production, EOL test as well as the evaluation of customer data.

### DA1

End-of-line function test with analysis of all available test run information (e.g. measurement data, log files, PLC data)

- Quality optimization
- Automated determination of meaningful test limits
- Time savings through avoidance of test redundancies in multi-stage manufacturing processes

### DA3

Analysis of data from EOL testing, production and development

- Derivation of the performance capability allows new variants to be defined without them having to be 100% field tested
- Time and cost savings
- Added value for product quality and processes

### DA2

Merging the results from DA1 with data from production

- Identification of influencing variables for process optimization
- Time and material savings through targeted improvement measures
- Increased delivery capability through reduction of the internal return rate

### DA4

Integration of customer usage data in data analytics

- Knowledge gain for the development of the next product generation
- Determination of real load spectrums allows for optimized service intervals (Example: ZF TraXon Predictive Maintenance)
- Added value for product quality and processes

## **ZF Group**

Division Industrial Technology  
Business Unit Test Systems  
94030 Passau  
Germany  
Phone +49 851 494-5529  
Fax +49 851 494-905529  
sales.it@zf.com

[www.zf.com/testsystems](http://www.zf.com/testsystems)



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