Endurance Testing: Practice

___ Developments only provide added value when they have passed real-life testing. Testing within engine developments is therefore extremely important for a wide variety of customer projects.

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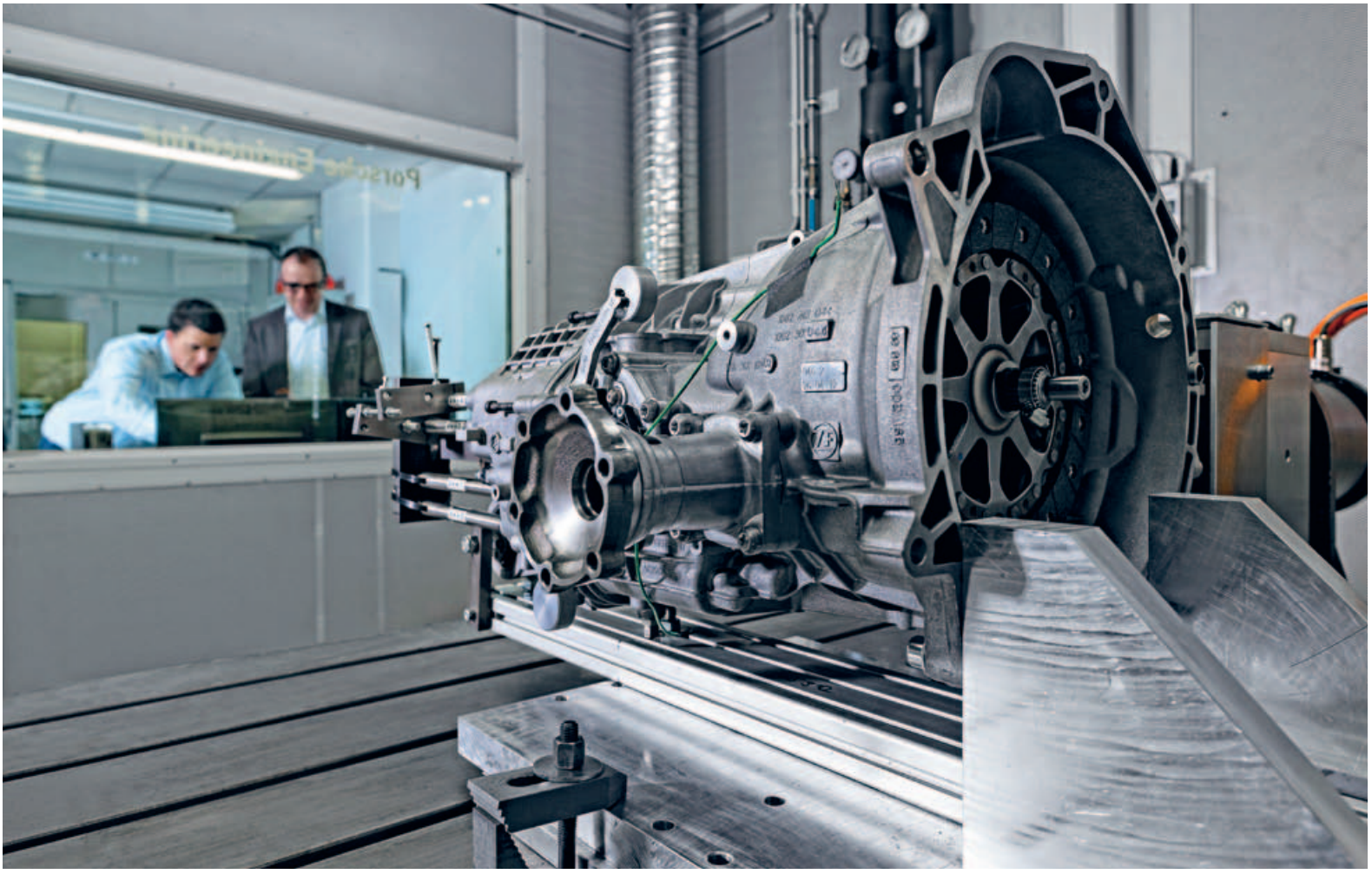
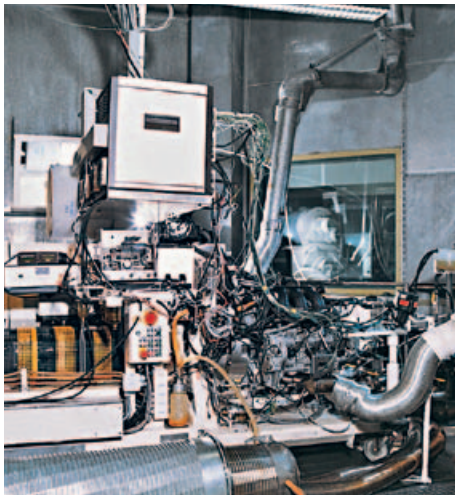
Photos: Jörg Eberl, Gabriele Torsello, archive



Testing at the Weissach Development Center: View of the engine acoustic chamber (left) and an engine on a test bench (right)



Porsche has always been at the forefront of trends and technologies in the area of engine development—both for its own sports cars and projects for external customers. But only when the theory has been confirmed in practice do the true benefits for the customer come through.

A broad spectrum of engine test benches

To efficiently test the very different types of engines, Porsche has a wide range of different test benches. Continuous investment ensures that all Porsche locations always have state-of-the-art technology to meet the demands of increasing product complexity and changing legal frameworks, which also place more stringent requirements on engine testing and the test benches required for it. From small test benches for testing components and systems to standard engine test benches and high-performance test benches used for motor racing purposes, Porsche has everything centrally located at a single site. It is possible to test the various drive variants, from front- and rear-wheel drive to all-wheel drive engines. The infrastructure is also in place for efficient testing of hybrid and electric motors.

Diverse environments and short distances

To simulate all of the different environmental conditions that an engine can be exposed to, the range of testing capabilities includes the engine climate pressure chamber and the dynamic high-performance powertrain test bench, among others. These facilities enable simulation of different temperatures and pressures to ensure that the engines can withstand a vast array of environmental conditions. In addition to the various test benches and other testing capabilities, another important factor is the close proximity to the specific departments and other areas and workshops. Short communication paths ensure direct exchange of expertise and knowledge.

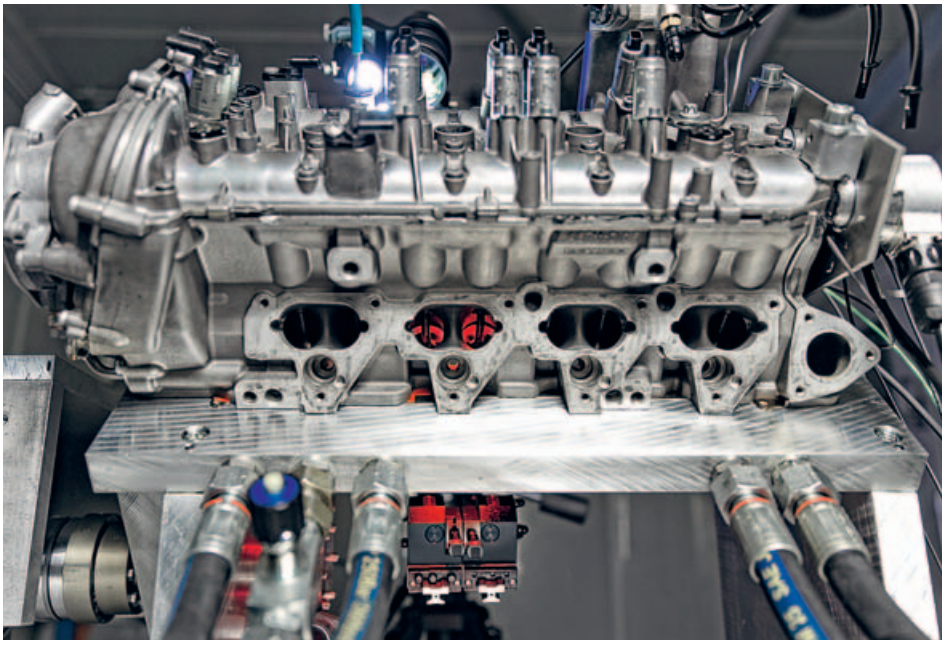
Customer-specific and multifunctional

Porsche Engineering also uses the test benches to conduct customer projects in a specific and efficient manner. The individual component test benches in particular offer the opportunity to accommodate the requests of customers not only from the automotive industry but also other sectors.

As the requirements for test equipment in development for external customers can vary widely from one project to another, the test facility itself must be designed with the greatest degree of variability in mind. To meet that challenge, the test facility is equipped for multifunctional use and is extremely flexible. This makes it possible to execute projects from different technological fields with great efficiency. ›

Porsche measurement technology

To record measured values for test objects, all test benches utilize Porsche-developed measurement technology (PMT), the fifth generation of which is currently being rolled out. This makes it possible to employ any given combination of different measurement modules for pressures, temperatures, voltages, and other variables. The measurement modules themselves are mobile and can also be used for measurements in the vehicle. Maintenance and calibration tasks are executed centrally at the Development Center in Weissach.



The Laser Doppler vibrometer measures lift and speed.

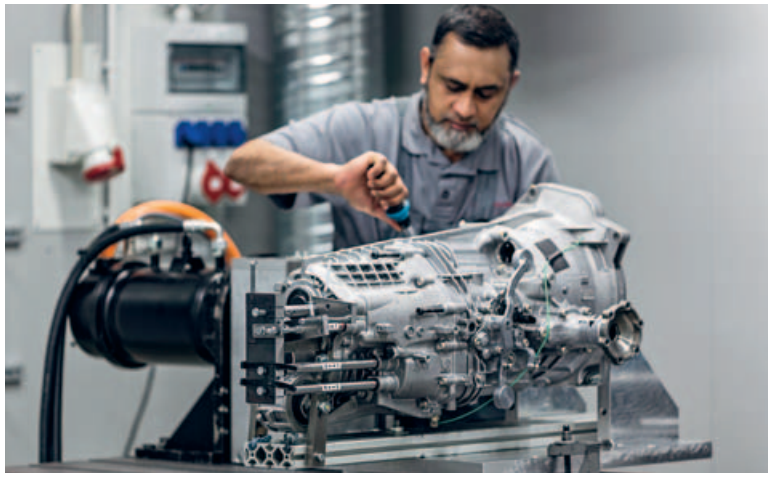
Intelligent test bench control

The test bench control is capable of simulating motor functions of control units that will be implemented in series ECUs (Engine Control Units) years later. One example is the variable valve-lift device, which controls valve-lift switching on engines in real time and with a crankshaft angle resolution of less than one degree.

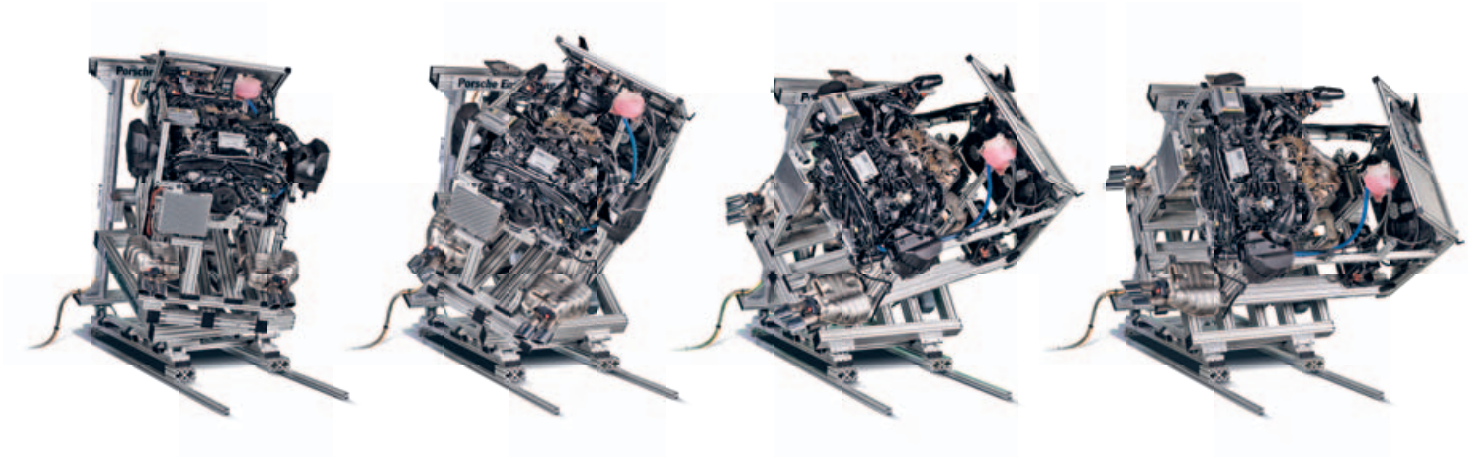
With these highly dynamic applications, extremely fast measurement of the test object is of the essence: mechanical defects or malfunctions must be detected without delay. Porsche Engineering has developed monitoring functions for some parameters that detect malfunctions within a five-degree crankshaft angle, trigger an emergency stop, and thus minimize any follow-on damages.

Dynamic valve drive measurement

To efficiently measure the dynamic characteristics of valve drive components, Porsche Engineering uses a test bench for taking measurements on mock-up cylinder heads. The cylinder head along with the control assembly is driven by a powerful asynchronous motor. A Laser Doppler vibrometer measures the lift and the speed of the valves. Processing and evaluating the values recorded at sampling rates of up to 400,000 Hertz makes it possible to draw conclusions about maximum permissible engine speeds, acoustic development, wear, and loads on components. Other parameters such as oil pressures, temperatures, torsional vibration, as well as signals from components applied with strain gauges are also used.



A transmission is mounted on the test bench.



The tilt test bench enables biaxial rotation of up to 60 degrees in any direction.

High-speed analyses

In many test applications, high-speed video cameras are used. This system makes it possible to visualize dynamic effects such as the oscillation forms of chains, valve springs, or the axial movements of cam segments in variable valve trains and later analyze them with image processing software.

Thanks to the modular structure of the test bench, in addition to valve drive measurements it is also possible to measure friction performance parameters on motored engines, engine components, or transmissions. Here high-precision torque flanges and oil conditioning with a very high control precision are used.

Hybrid and electric motors

The regenerative capability of the asynchronous motor in conjunction with a mobile 60 kW DC power supply also enables testing of electric drives such as belt alternator starters, for which the important breakaway torque at zero rpm as well as the efficiency in generation mode is determined.

In light of the rising hybridization and electrification of vehicles, the battery simulation systems required for efficient testing are already in use. There is also a 250 kW DC power supply available that provides the electric motors with the required power or feeds the generated electricity back into the grid when working in generator mode. To condition the electric motor and associated power electronics, a conditioning device that can test both systems separately at different temperatures between –40 degrees Celsius and +120 degrees Celsius is used. To determine the efficiency of test objects, an electrical power measurement device is utilized.

Tilt test bench

To simulate cornering maneuvers or braking and accelerating, engines can be mounted on a tilt test bench and tested to maximum engine speeds tilted up to 60 degrees over horizontal in all directions. The tilt test bench itself is attached to an air-suspension test bed frame with a leveling system, which in its lowered position is covered by plates and thus enables a level surface. In these tilting tests, the quality of oil aeration measurements is given particular attention.

Measurement of industrial engines

In testing industrial engines, thermodynamic measurement plays an important role. Engines for emergency generators, lawn mowers, or manually operated forestry equipment require a special type of testing that impacts the preparation ›

ADA test bench for testing exhaust emissions

of the test benches and the measuring procedure. The displacement can range from 25 cm³ to roughly 500 cm³. Eddy current brakes are used for the measurement of engine torque, while fuel consumption is measured gravimetrically.

Exhaust sensors

Exhaust gas measurement systems are in place to analyze exhaust gas. These systems extract very small sample amounts from the test object to avoid impacting the gas charge cycle, particularly in the case of 2-stroke engines.

To ensure that engine developments also fulfill customer-specific and legal requirements with regard to exhaust gas and emissions, more precise exhaust gas sensors can be utilized. In the Porsche Engineering center for environmental protection, vehicles are subjected to comprehensive emissions testing. In this regard Porsche has engaged in a long-standing collaboration with the Abgaszentrum der Automobilindustrie (ADA), the German exhaust emissions center for the automotive industry, for which Porsche operates special test benches. These include a hydraulic shock test bench with which protective tubes from AFR (Air Fuel Ratio) and NOx sensors are analyzed, as well as a test bench for the evaluation of particle sensors.

Challenges are welcome

The special thing about the Porsche engine testing facility is its wide applicability: both in terms of capability and flexible structure, it has all the prerequisites for efficient testing. The flexible design of the test benches and the fast configurability of the measurement technology make it possible to implement a vast range of tests, either for sports cars or other challenges. And when the development has proven its success in testing, there's just one more thing: the first test drive on the track …

911 (TYPE 991) Fuel consumption (combined): 12.4–8.2 l/100 km; CO_2 emissions: 289–194 g/km