

# SPECTRUM

Technology Highlights and R & D Activities at FEV

Issue 35, September 2007



## Basic Data

Federal State:	Sachsen-Anhalt
County:	Anhalt-Bitterfeld
Community:	Bitterfeld
Coordination:	51° 32' N, 12° 13' O



Aerial Photo Brehna 16.07.2007



## The New FEV Endurance Test Center in Brehna, near Leipzig

As a result of strong demand for engine and powertrain endurance testing, FEV has established a new facility in Brehna near Leipzig in Germany. Called the FEV Dauerlaufprüfzentrum GmbH (DLP), this test center is being constructed to allow FEV to conduct special test requests and comprehensive endurance test programs for its customers. The test center covers an area of approximately 60,000 m<sup>2</sup> and offers direct access to the German autobahn and the nearby airport.

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From an economic standpoint, efficient process sequencing and high plant availability are key factors for success in the construction of such a test facility. The DLP will be equipped with advanced testing technology that will support endurance testing of future engine generations. FEV DLP has attached special importance to a sophisticated logistical concept as well as to the definition and organization of effective processes in the workshops and in test rig operations. All of the features of the building, the mechanical building services and the test rig technology were optimized for high plant availability, including the necessary redundancies. DLP will feature highly-standardized test rigs that can be operated dynamically; the facility will also feature a largely modular design to accommodate conditioning units. These facility features are prerequisites for flexible test rig assignment and will support quick startup of the test cycles.

The test facility is configured into several interconnected wings, with a usable floor space of approximately 9,000 m<sup>2</sup>.

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**3<sup>rd</sup> International Automotive Workshop  
„Direct Injection for Gasoline Engines“**

September 17<sup>th</sup>/18<sup>th</sup> 2007, Spa, Belgium

# 35



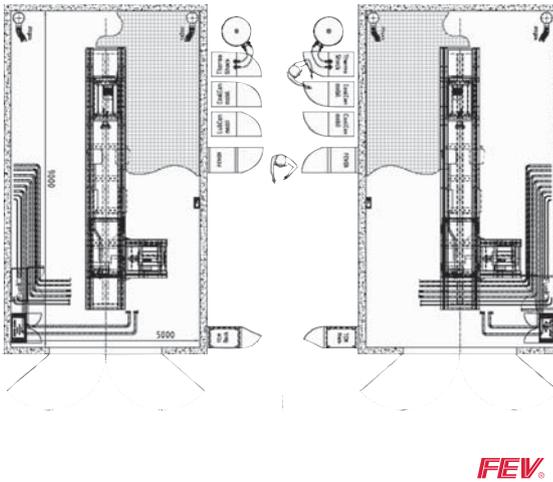


Fig. 2: Floor Plan of an Engine Test Bench, Variable for Longitudinal and Transversal Installation

and powertrains. They contain a comprehensive test program for validation and release for SOP and, at the same time, minimize the number of individual test cycles. In addition to FEV's own test catalog, customer-specific test programs are also conducted.

Test programs in Brehna are conducted on fully automated test rigs, based on the latest state of the art, which includes:

- Automatic safety monitoring of defined shut-off limits
- Large number of measuring channels
- Potential for data pick-up from the Engine Control Unit (ECU)
- Possibility for loading auxiliary units
- Configuration of the original exhaust gas system, including aftertreatment systems
- Possibility for analyzing the raw exhaust gas concentrations during the test cycle
- Availability of independent cooling systems (hot/cold) for fast thermal cycles
- Analysis of all operating liquids (< 24 hours response time),
- Use of conventional fuels or special fuels
- Extensive ratings for all tested engine parts, including photographic documentation
- Comprehensive reporting on progress and failures, if applicable

The heart of the test center in Brehna is a control room where all parameters of the test specimen, the test rig instruments and the central technical equipment converge. From this location, all of the test rigs in the endurance test cycle can be monitored and controlled. The control room is connected with its

electronic counterpart – a virtual control room – at FEV in Aachen, Germany, so that all operating and test specimen data are immediately available for discussion and assessment in the development departments at FEV's headquarters, whenever needed. If required, such a virtual control room can also be installed at the customer's site, so that they can observe their own test runs on the test rigs and quickly initiate any required changes.

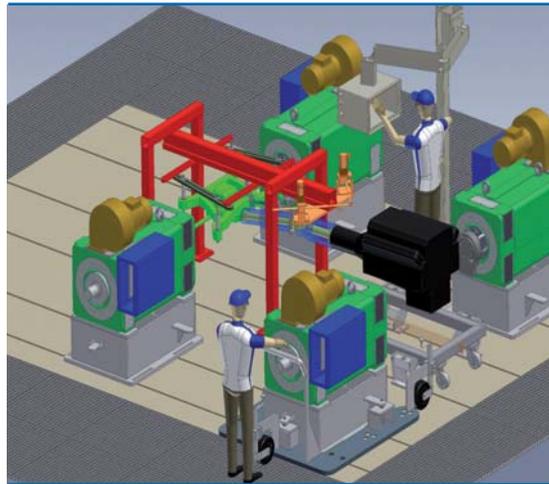


Fig. 3: 3D-View of an Engine Test Bench

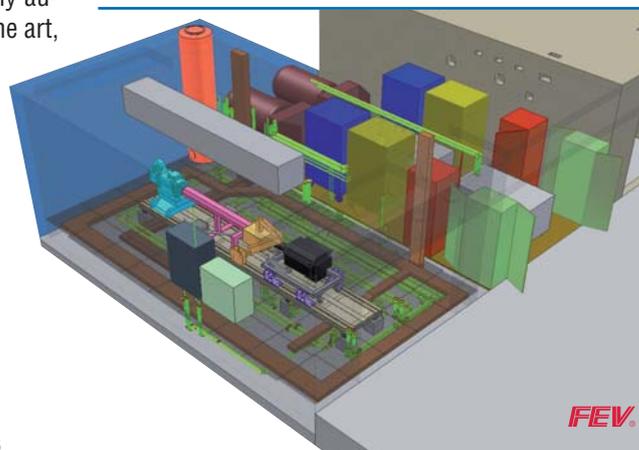


Fig. 4: 3D-View of a Powertrain Test Bench

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## Hybrid Powertrain Test Cell Capabilities

FEV recently completed an expansion of its North American Headquarters. This expansion included the addition of four hybrid powertrain test sites, which are believed to be one of the only non-OEM, emission compliant, hybrid powertrain test cells in the United States. In total, FEV's North American Technical Center can now support its customers with six hybrid powertrain test sites (s. fig. 1). FEV offers hybrid development, testing and optimization services to OEMs, battery suppliers and hybrid electric motor suppliers that need to develop hybrid powertrains in a technologically advanced environment dedicated to sustained mobility through hybrid applications.

All hybrid powertrain test sites (s. fig. 2) are fully transient capable. Full hybrid powertrain test cells differ from conventional powertrain test cells based mainly on dynamometer capability and battery emulation/



Fig. 1: Hybrid Test Cell Controlling

simulation. The transient dynamometers used in FEV's new cells satisfy hybrid development needs for operating a powertrain at rated torque with 0 rpm while still being able to achieve high output speeds of up to 8,000 rpm. Each test site also utilizes a battery emulation system (ABC 150), which replaces the hybrid vehicle battery with a high-voltage source. The cells have the capability to run with battery simulator, with the high voltage battery, or use the unit to charge the high voltage battery.

In addition to the battery emulation system, FEV has developed a Restbus Simulation system, which simulates output signals that would exist from various vehicle systems. These signals are relayed to the Engine and Hybrid Control Units so that the systems function properly. The Restbus Simulator was developed

as a communication system to operate the battery emulator, which can command particular voltages, as required by specific testing conditions.

Hybrid test cells also require many safety features due to the high voltage environment. Features have been added, such as component isolation and electrical indicators (lights and buzzers) to alert the test cell technicians when high voltage is present.

Similar to conventional powertrain development test cells, each of the new hybrid cells are utilized for:

- powertrain and controller development
- calibration
- benchmarking
- validation and durability testing



Fig. 2: Hybrid Test Cell

These cells, combined with FEV's experienced hybrid staff, provide our customers with the flexibility and technology to develop a wide range of current and future hybrid systems, which can reduce the overall development time by optimizing the integration process earlier in the vehicle development cycle and can aid in generating a faster time to market based on industry demand.

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## Mechanical Testing

During the last few decades, the use of computers in the engine development process has been firmly established. Engine mechanical design, especially for subsystems, is now typically completed through simulations. During this phase, Computational Fluid Dynamics (CFD), Finite Element Method (FEM) as well as Multi-Body Systems (MBS) analysis are applied.

The desire for a more detailed optimization has not yet eliminated the need for testing and safety runs. For the foreseeable future this will remain the case. Nonetheless, cost-intensive test benches and vehicle tests will always remain conflict with the desire for low-cost development efforts.

Modern mechanical development strategies are characterized by intensive model-based optimization of a virtual prototype that is followed by validation testing on high-level physical prototypes. It is only through this approach that modern engines can be brought closer and closer to the limits of their mechanical design. To further improve the established Computer-Aided Engineering (CAE) methods, FEV created the “FEV Test Catalog”. Based on extensive project experience, FEV collected and established a comprehensive database of test procedures, process guidance and benchmark data to achieve a more effective and goal-oriented mechanical development process (s. fig. 1). This test catalog has now been successfully applied to numerous mass production development programs.

FEV offers a wide range of mechanical testing activities, which are based on available technologies and are divided into three main categories:

Suitable component testing provides a cost-effective verification of simulation results and a validation of the engine subsystems that are affected. Component investigations contribute to reducing development time, because they can be performed before the completed engine stages are available. FEV distinguishes between static component testing, pulse testing and dynamic rig testing.

Despite the high standards achieved by modern component testing, especially with regard to the transferability of test results to a complete engine, functional testing under fired conditions is still indispensable. According to the specific project requirements, a test program is selected from the “FEV Test Catalog” (such as a piston scuff test, engine inclination test, oil dilution test, over-speed test or deep thermo-shock test). In addition, FEV is also experienced in carrying out customer-specific test programs.

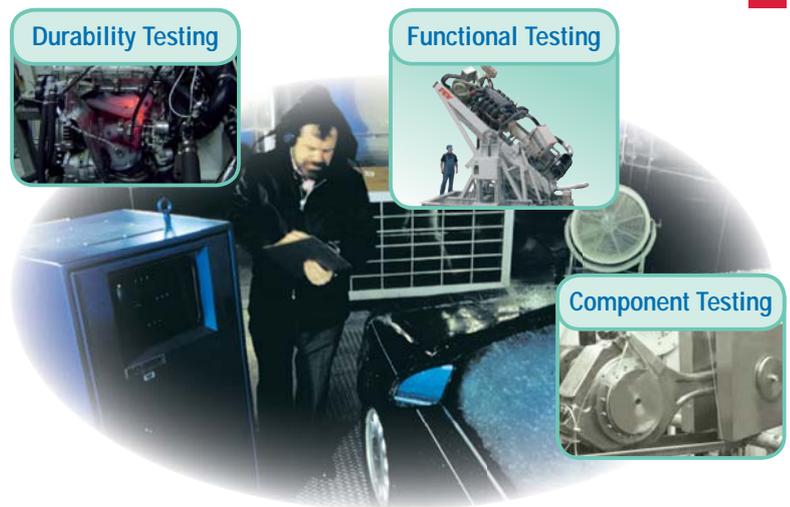


Fig. 1: Mechanical Testing

FEV

Durability Testing is obligatory to verify the engine's life span before its release for Start of Production (SOP). Test bench durability runs have the advantage of allowing very high reproducibility as they enable a controlled adjustment of the boundary conditions. The driver and environmental factors do not affect test results; therefore, test bench investigations are especially suitable for statistical analyses. Typical of the modeling phase, test cell runs imperfectly recreate real world driving conditions. Nevertheless, these artificial conditions can be used advantageously for the acceleration of deterioration or damage processes. Those tests are performed in all of the FEV mechanical test centers on automated state-of-the-art test benches, 24 hours a day and seven days a week.

A variety of durability tests are typically performed on combustion engines; however, in-vehicle endurance tests come closest to reproducing real driving conditions for the application. These realistic in-vehicle endurance tests require long run times and high levels of personnel expenditure. Conversely, these vehicle tests deliver results for other disciplines almost as a by-product, including data concerning the chassis, the vehicle body or the drivetrain. The vehicle test programs, like design programs, focus on the testing of worst case scenarios that are defined under such conditions as highway (→ full load) or racetrack, or represent driving cycles such as taxi, low load or a test run according to the client's specification. The program selection is made with regard to the characteristics of the target vehicle and its potential driving profile.

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## Fleet Testing

Fleet testing is a simultaneous assessment of robustness, emission system deterioration, and a representation of real life mileage accumulation.

The tightening of European emission control legislation to meet the 160,000 km mileage requirements demands a high-quality and well-structured check of conformity with real life vehicle durability testing. The key to success with this issue is providing a close collaboration between the durability team and the technical specialists.

through heat of South Africa as well as directly to the locations of our customers. FEV also offers the possibility of direct collaboration in durability testing using customer-approved test routes for specific programs.

FEV drivers operate vehicles around-the-clock. We provide on-call technicians and engineers to support the activities. The scope of service includes scheduling, management, evaluation, accompanying documentation, troubleshooting and analysis as well as providing inputs to the development process in the form of suggestions for improvement. The integration of the durability team into the FEV vehicle application competence center ensures the availability of expert

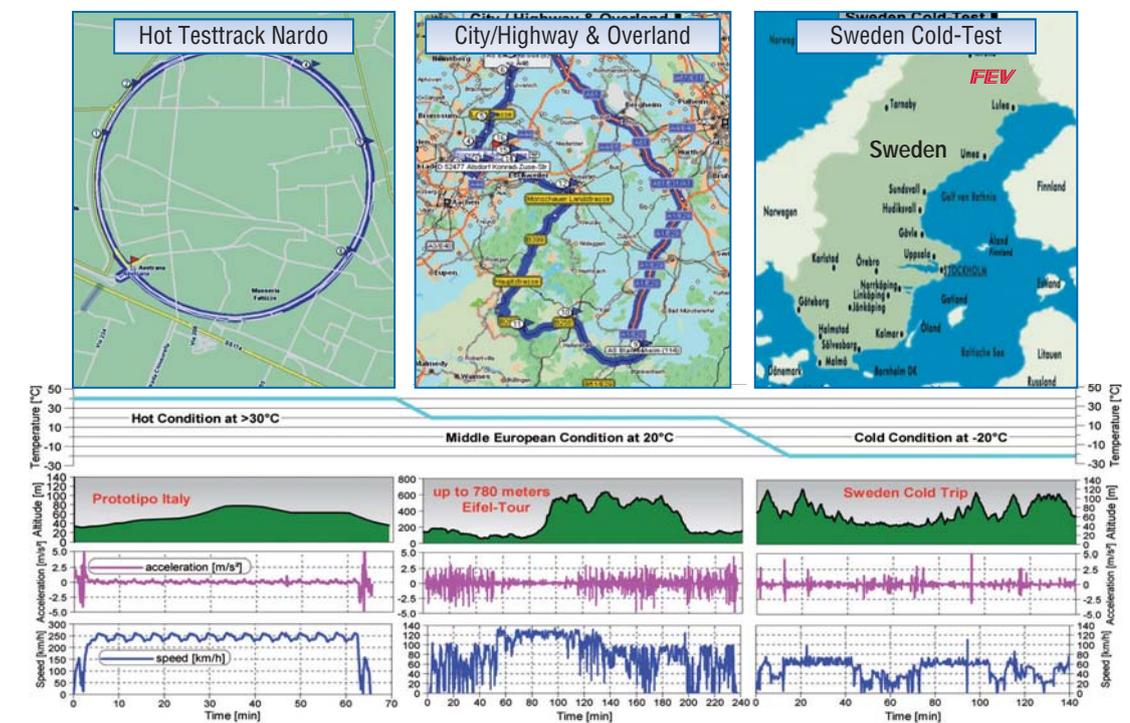


Fig. 1: Fleet Testing Europe

FEV has been successfully performing vehicle durability projects (s. fig. 1) for nearly all of the worldwide OEMs for more than 11 years, which provides our customers with a level of confidence that their goals will be achieved. FEV provides a specially trained and experienced driver pool that has operated test vehicles for more than 22 million accident-free kilometers. The members of this team follow a driver's profile, which was specially developed for these tasks. The profiles are specific with regard to the handling of experimental vehicles as well as all technology and safety aspects. Testing programs are conducted using a managed fleet involving vehicle operation on a group of defined worldwide test routes, ensuring statistically valid durability results. FEV drivers operate these managed fleet vehicles through Scandinavian winters, into the heights of the Sierra Nevada Mountains,

knowledge to the vehicle program and enables FEV to provide a complete set of services for durability testing. This all-inclusive durability testing package also includes an emission dynamometer to complete cyclic emission tests (SULEV standard); a chemistry laboratory, as well as a large workshop and highly-skilled workforce.

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\* In addition, view the report in Spectrum No. 34 (Application in USA and China)



## FEV Test & Instrumentation Systems Worldwide - Global as our customers

During the past several years FEV has continued to establish itself as an increasingly mainstream supplier of test and Instrumentation systems. It started with the development and manufacture of individual test cell components which, at the time, were intended to meet our own requirements.

Today however, our business activities have greatly expanded to cover more than just first class quality and reliability. In addition to test and instrumentation equipment, we also offer the engineering services that are necessary to create complete, ready-to-use test cells. The range of services extends from a single component or endurance test site up to complete research and development test centers and (more specific to engine manufacturers): hot test cells.

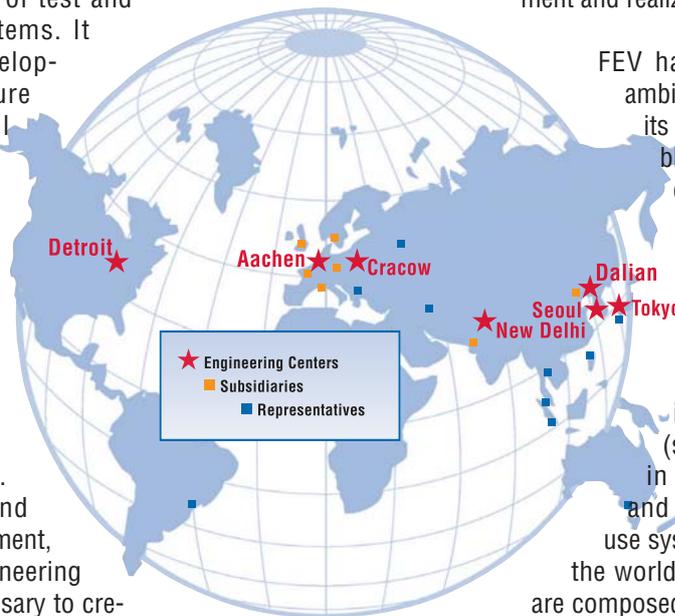
We give special attention to the realization custom solutions that are both technically and cost-effectively superior, while satisfying all of our customer's requirements.

The demands placed upon the true "Global Players" in this business have increased substantially beyond the pure technical and commercial knowledge aspects. Success in this field requires a global presence, combined with rather precise knowledge of different local market conditions and the logistical ability to take full advantage of the location. Our customers are conducting planning in Europe, Asia and/or North America while, in some cases, developing, producing and testing in other parts of the world.

Successful development and the establishment of new locations in foreign countries not only poses a challenge to the company's professional competence, but also requires great efforts to consider local laws, rules and conventions and to convert them into an advantage for each individual project. Knowledge of supplier and service provider safety regulations and

acceptance specifications support the handling of local subcontractor conditions. Even compliance with simple transportation and import regulations requires a high degree of native country-specific knowledge and experience.

Facilities intended for the same testing demands could be in fact very different regarding the utilization of local resources, but they always have the following three criteria in common: Quality, investment and realization schedule.



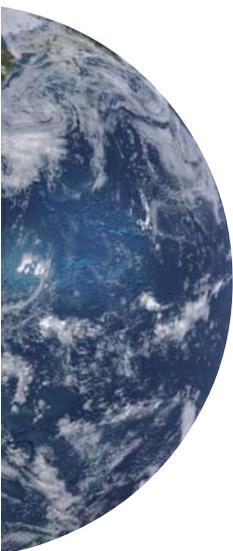
FEV has always had the ambition to be as close to its customers as possible. We pursue global expansion with development and production locations near our customers. Currently, we are located in more than 30 countries, including Germany (s. fig. 1), China and in the United States and we have ready-to-use systems placed around the world. Our project teams are composed of employees from many different continents and we are able to offer competent contact personnel to our customers at all locations.



Fig. 1: FEV World Headquarters, Aachen, Germany

Consideration of local conditions as well as technical and regulatory demands represents a main part of our service package.

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## 3<sup>rd</sup> Day of the Powertrain at FEV China

China, with its fast growing population, is increasingly becoming a significant part of the global discussion concerning CO<sub>2</sub> reduction. "Mobility and CO<sub>2</sub> Reduction" is also the focus of the "3<sup>rd</sup> Day of the Powertrain," which is being organized by FEV China and will be held on September 18, 2007 in Dalian, China. During this one-day event, experts from the automotive industry, international mineral oil industry, international suppliers, Tsinghua University and FEV will present and discuss ideas and solutions for CO<sub>2</sub> reduction. The conference will be conducted in both English and Chinese. FEV China will also provide translation services.

FEV China Co., Ltd. was founded in 2004 in the northeastern Chinese high-tech metropolis of Dalian to provide powertrain engineering services and test systems to the booming Chinese and neighboring Asian automotive markets.

FEV China is serving its Chinese and international clientele with powertrain and test and instrumentation projects, sourcing support, supply base development, as well as with feature-rich test systems for both powertrain development and quality assurance for production. FEV China's service specialists offer quick response times as well as after-sales and service support for almost 100 test bench installations across China.



To obtain the conference program please contact:  
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## 3<sup>rd</sup> International Automotive Workshop - „Direct Injection for Gasoline Engines“ September 17<sup>th</sup>/18<sup>th</sup> 2007, Spa, Belgium

The potential of gasoline direct injection with regard to power, torque, and fuel economy makes it a key technology for future gasoline engines.

Recent advances in fuel injection equipment combined with new combustion system processes, air charging techniques, and exhaust aftertreatment, enable better exploitation of the fuel economy potential, while still meeting customer demands for more power and torque. Demonstrating these complex systems requires the development and application of new development methodologies.

Robustness plays a decisive role throughout the entire development process. To achieve this, progressive application methodologies are necessary to realize the potential of DI gasoline operation as a perceivable customer benefits in daily driving conditions.

Experts from the automotive and supplier industry will clarify the development challenges and discuss their conversion into production, with a focus on:

- Component Technology
- Development Methodology
- Combustion Systems
- Vehicle Calibration

The workshop provides ample space for individual discussions and the plenary discussions. The complete workshop program can be found in [www.fev-events.com](http://www.fev-events.com).

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